2 Wood and Woodworking Product Industries

2.1 General

In this sector, 759 establishments are registered, representing a significant portion of the manufacturing industry in the country. Of the total, 711 establishments (94%) are small enterprises having capital of less than RO.25,000. On the other hand, 14 (1.8%) are large enterprises with capital of RO.100,000 or larger. The sector is divided into the following 4 subsectors:

(1) Wood milling (sector code: 3311)
(2) Saw/wood mills (sector code: 3312)
(3) Wood and cork products (sector code: 3319)
(4) Wood furniture (sector code: 3320)

While a clear distinction between subsectors (1) and (4) has not been made, major characteristics common to these sectors are: they are all dominated by small enterprises with capital of less than RO.25,000; and most of them are concentrated in three areas namely, Muscat, Al Batinah, and A'Sharqiya, e.g., 405 out of 585 establishments (69%) of subsector (1), and 153 out of 173 (90%) of subsector (4). In particular, concentration in A'Sharqiya exceeds that in Muscat, indicating that the wood-related industries are formed particularly in the region.

On the other hand, only one enterprise of less than RO.25,000 in capital is registered in each of subsectors (2) and (3).

Wood used for the industry is all imported.

2.2 Current Status by Subsector

2.2.1 Wood milling

This is the largest subsector in the industry comprising of 585 establishments. Of this total, 551 (94%) are small enterprises of less than RO.25,000 in capital, and large enterprises with capital of RO.100,000 are limited to 8, all located in Muscat.

In terms of geographical distribution, 406 establishments (69%) are located in Muscat (130), Al Batinah (133), and A'Sharqiya (142). Except for 12 establishments in Muscat and 1 in Dhofar, most of them are medium and small-sized enterprises of less than RO.75,000.

2.2.2 Wood furniture

2.2.2.1 Description of business

The subsector also occupies an important position in the country's manufacturing sector, with 173 establishments being registered, excluding the metal furniture subsector which is classified under metal products.

As for size distribution, 159 are small enterprises with capital of less than RO.25,000 (92%), compared to only 6 large enterprises of RO.100,000 in capital or larger, 5 in Muscat and 1 in Dhofar.

Geographically, 155 establishments (over 60% of total) are concentrated in Muscat (66) and Al Batinah (39) suggesting that the subsector is a market-oriented industry. Except for Muscat, most of them are medium or small-sized. A notable feature is relatively high concentration in A'Sharqiya where 50 establishments are located, followed by Muscat.

Wood furniture manufacturers in the country can be divided into two clearly distinguishable groups.

Medium and small-sized enterprises, which dominate the industry in number, are mainly focused on "flexible production strategy" in manufacturing relatively simple and small furniture by orders of local customers. They mainly rely on manual work, except for simple woodworking machinery. Wood materials are purchased from importers or via retailers. These small enterprises are mainly located in Muscat and A'Sharqiya (particular, Sur).

Notably, wood furniture makers in Sur are observed to have obvious characteristics. In the area, a large number of small furniture makers are highly concentrated; in an area, out of around 10 small workshops are accommodated in the form of terrace houses, and 4-5 furniture manufacturers exist. Clearly, this concentration reflects the historical heritage of the wood furniture industry in the area, where woodworking technology and culture represented by construction of dhows have flourished. Wood materials were readily obtained from the Indian subcontinent in the past (at present, few wood exports are made from the subcontinent).

Some of relatively large wood furniture shops in the area manufacture large furniture and fixture with engraved traditional patterns, such as doors, window frames, and built-in cabinets designed for Arabic style buildings made from manual processing of wood materials imported from Southeast Asia. The cutting, shaping and engraving of wood materials are done by one craftsman, who creates and keeps design drawings in his mind. These shops do not seem to compete with small "cottage" manufacturers in the same area.

Compared to these small enterprises, large enterprises having working capital of RO.100,000 or larger operate in a very different way. Most of them started as importers of foreign high-grade furniture and diversified to furniture manufacturing when building construction boomed in the country, leading to an accompanying demand for furniture Many are still selling imported furniture as well.

While some of them specializes in the manufacture of store-sold furniture, many supply products and services for large projects, including hotels, commercial buildings, government buildings, and mansions, ranging from built-in furniture, wood doors and windows, to interior decorations including carpets and curtains, and installation. Thus, they are viewed as interior contractors, rather than furniture manufacturers.

To provide a wide range of services involved in the turn-key based interior project, the enterprises have designers and draftsmen who prepare drawings based on designers' sketches, and employs a variety of woodworking machinery. Thus, they have introduced latest production technologies and management techniques from industrialized nations. They import wood materials and laminated lumber from various countries. In particular, high-grade wood materials for furniture are imported directly through their own routes. Their products and services are excellent in design and quality and are supplied to other GCCs. However, these enterprises have grown side by side with the construction boom in Oman and faced a major setback in the 1980s when construction demand became sluggish.

Thus, the large furniture makers are operating in a market different from medium- and small-sized enterprises which handle small-lot and highly customized orders. This explains why the latter two are seldom directly competing and, thus are considered to be in different domains.

Finally, the steel furniture industry (sector code: 3812) mostly produces standard products that are supplied to schools and offices. They do not directly compete with large furniture makers specializing in high-grade products nor with medium and small-sized enterprises.

2.2.2.2 Sales revenues and cost structure

Large enterprises in Muscat have two major revenue sources, contract service and store sales (imported and own products), with proportion varying greatly among companies. A company earns 90% of its total revenues from contract service, and store sales accounts for remaining 10%. In fact, 65% of the company's sales come from projects awarded from GCCs. Another company earns 60% from contract service, of which only 30% come from its own products. Remaining 40% come from furniture sales, and imported furniture accounts for sizable portions. The company deals with major furniture makers throughout the world.

The large enterprises sometimes work with others to handle a large project that goes beyond the capacity of a single company. However, no cooperation is practiced between large and small enterprises because of disparities in quality and technology.

2.2.2.3 Major issues and future prospect

Clearly, the subsector consists of two distinctively different segments, one serving local and small-lot demand, and another meeting demand related to large construction projects.

The large enterprises have emerged and grown under the favorable wind of the construction boom in the country. As the spending spree has subsided, they have to become adaptable to the changing market environment. It does not necessarily mean that they have to pursue local and small lot orders in the domestic market served by medium- and small-sized enterprises. Rather, they should aim for the high-grade market, including export markets if possible, by offering better designs, material and workmanship.

Contract service presents another opportunity. They may carry out foreign projects by exporting furniture components processed at their own shops, and assembling them on site. Also, exports of wood furniture components will become feasible if high quality wood materials (particularly hardwood) can be obtained at low cost. At preset, however, the raw material hard wood they obtain is imported from Southeast Asian countries, and, therefore, Oman will find difficulty to export their products to the export market where these countries are also exporting.

On the other hand, medium and small-sized enterprises have to rely solely on new and replacement demand in the domestic market, and cannot expect significant growth even if personal income grows and the standard of living rises on a continuous basis.

Generally speaking, they can expect some benefits from large enterprises as they grow to become a major export industry, by using them as subcontractors or suppliers. In practice, however, quality limitations in smaller enterprises and excess production capacity suffered by many large enterprises will not likely create such vertical division of labor in the foreseeable future.

Finally, there are furniture makers in Sur, which manufacture Arabic-style gates, doors, windows and built-in furniture using traditional design and production techniques, and are exported to other GCCs. While these products can remain popular with the continued preference for traditional building style and design, it cannot be avoided for it to be the subject of preservation as craft products like dhow, since the lifestyles inevitably change among local people.

3 Textile and Apparel Industries

The textile industry in Oman consists of weaving, dyeing and finishing in the upper stream, but it has no spinning mill, thus importing all yarns required for textile production. In the downstream, small–scale apparel manufacturers (tailors) serve domestic market, and relatively large makers mainly export products to the US. In addition, there are wholesalers who distribute domestic and imported textile mill products.

3.1 Textile Industry

3.1.1 Domestic market

Textile demand for clothing in Oman is fairly small reflective of a small population. According to a FAO survey, textile consumption per capita in the country was 2.8kg for natural fiber and 4.9kg for man–made fiber, totaling 7.7kg (as of 1989). The total consumption per capita is below the world average (8.1kg), but it is much higher than the average in Southeast Asia (5.3kg). It is less than one half compared to Saudi Arabia and Bahrain, 21.0kg and 17.0kg respectively. On the basis of the per–capita data, the total volume of textile consumption in Oman is estimated at 11,400 tons, which are divided into 4,100 tons for natural fibers and 7,300 tons for man–made fibers. Note that the figures include consumption by apparel makers specialized in export, so that net domestic consumption is smaller. Import volume of textiles and textile products given trade statistics indicates textile (woven fabric) imports, not including those for re–exports and production of export apparel products, totalling 6,000 – 7,000 tons, imports of textile products (including carpets and others) totalling 2,000 – 3,000 tons, and yarns for woven fabric production around 500 tons. From these figures, net textile consumption in the country is estimated to range between 8,500 – 10,500 tons.

3.1.2 GCC countries and Yemen market

Net consumption in neighboring countries can also be estimated from the FAO survey. A combined total for the GCC countries (Saudi Arabia, the UAE, Kuwait, Bahrain, Qatar, and Oman) is approximately 450,000 tons (170,000 tons for natural fibers, and 280,000 tons for man–made fibers). Among them, Saudi Arabia consumes slightly less than 340,000 tons and accounts for 75% in total accounted for relatively large population and high per–capita consumption. If Yemen's consumption estimated as 90,000 tons is added, the region consumes around 540,000 tons.

3.1.3 Textile mill

In Oman, there is only one textile mill that is operated by Oman Textile Mill in Muscat. The mill produces a wide variety of woven fabrics used for dishdasha, dress, and men's cloth from cotton, polyester and blended yarns. In addition to weaving, it does dyeing and printing. The company does not have a spinning mill, and imports all of yarns consumed for weaving mainly from India. This textile mill has the largest production capacity among the GCC countries. Woven fabrics produced at the mill is mainly supplied to the domestic market and partially exported to the GCC countries. In fact, the mill's supply meets only 10% of domestic demand for woven fabrics. The small market share is attributable to the mill's limited product line, and strong competition from imported products. As a result, the mill's capacity utilization rate on the average is less than half.

There is a factory making tents, which produces specially treated cloth. The production capacity is very small.

3.1.4 Major issues facing the textile industry

As discussed above, the textile industry in Oman is not established in full-scale without spinning and related units due to the small domestic market, and sole reliance on imports. Apparel making, which is a major exporting industry, do not contribute much to the economy as they import most of raw materials. Figure A1-3-1 shows an estimated flow of yarns and woven fabrics in the industry, indicating a very limited industrial linkage.

The immediate task for the textile industry is to raise the capacity utilization of Oman Textile Mill. This should be accomplished through (1) the improvement of competitiveness against imported products through product diversification and quality improvement, together with step-up marketing efforts targeting the domestic and GCC markets, and (2) production of woven fabrics for apparel makers, both in the country and the UAE.

Dependence on imported raw materials makes the country less competitive against India, Pakistan and other raw cotton producing countries. In synthetic fiber-based production, however, the country can procure polyester and other synthetic yarns or blended yarns at lower costs than India and Pakistan, and thus can compete with these countries. Also, if production expands to a sufficient size, the mill will afford to have a spinning facility that will lower raw material cost and improve competitiveness. Furthermore, employment of expatriate skilled workers will enable diversification of product lines based on quality woven fabrics, ultimately exporting to markets other than the GCC countries.

3.2 Apparel Industry

3.2.1 Apparel makers for the domestic market

There are many tailors in the country that satisfy domestic demand. They produce traditional clothing by using fabrics bought from wholesalers or supplied by customers. Most of tailors seem to employ 2–3 persons and have 1–2 sewing machines. They are everywhere and have not grown beyond the cottage or backyard industry. There is one company which produces traditional clothing (Dishdasha) at a factory. It employs around 150 workers, most of which are expatriates. The company buys part of fabrics from Oman Textile Mill.

3.2.2 Apparel makers for export

In Oman apparel production for the exports started in 1989 and has been expanding rapidly. The boom was initiated by trading companies in the US and Hong Kong, specialized in apparel exports to the US.

Ready–made garments for exports produced in Oman are mainly outwear using cotton and synthetic fabrics in large varieties. The US accounts for approximately 95% of garment exports from Oman. Remaining 5% goes to Canada and the EC. The following table shows current exports of garments from Oman.

Garment Exports from Oman

	Volume (thousand dozens)	Value (million US$)
1991	970	42.20
1992	1,870	83.00
1993	1,710	85.00
1994*	1,030	56.00

Note: 6 months up to the end of June 1994

Source: Ministry of Commerce and Industry

The apparel industry has successfully grown to a major non-oil export industry. The rapid increase in imports from Oman, however, prompted the US government to impose import quota on garments from the country in 1993 and onward. The import quota is agreed annually by the two governments. For the period between 1994 and 1996, however, they have agreed to allow an annual 5% increase.

At present 29 apparel makers are operating in the country, and most of them were established in or after 1986. They produce more or less similar products, without significant difference in quality or market. 22 companies are located in Muscat and 24 have equity capital of RO.100,000 or more. There is no knitting mill operated by enterprises of over RO.25,000 in capital registered with the Ministry of Commerce and Industry. On the other hand, among enterprises classified as apparel makers with capital of RO.100,000 or more , five have license for knitwear production, with registered production capacity of 5.8 million pieces (480,000 dozens). Other 23 apparel makers with over RO.100,000 in capital have production capacity of 26.5 million pieces (2.2 million dozens).

These companies basically undertake subcontracted production from buyers' orders. They import raw materials – woven fabrics, yarns, and accessories (e.g., buttons, zippers) – from India, Hong Kong, and Taiwan according to specifications indicated by buyers, and make garments on the basis of designs and patterns supplied by buyers. Some of them produce garments for mid-range consumers, but most of them produce low-end products sold at US supermarkets and discount stores. Similarly, knitwear makers import knitted fabrics from Pakistan and other countries and make low-price T-shirts and underwear.

Most factories are operated by Pakistani or Indian expatriate managers or supervisors employed under contract, including marketing. All the factories employ expatriate workers from India, Pakistan, Sri Lanka, and Bangladesh. These expatriate workers seem to have a relatively high level of working skills. There are some Omani workers who are generally engaged in unskilled jobs at office or shop.

Value-added of apparel production in Oman is estimated in the range between 15% and 30% of FOB price, major portions of which are labor cost. Since many of workers are expatriate, sizable portions of salaries and wages paid at the garment factories are transferred to foreign countries.

3.2.3 Issues facing the export apparel industry in Oman, and future tasks

Export apparel manufacturers in Oman supply products to low-end and middle-class consumer markets. Their production is in a relatively small scale ranging 50 to 200 sewing machines installed.

The labor cost of the apparel industry is relatively high. The wages paid to Indian and Sri Lanka workers working in Oman averaged at US$150 per month. In addition, employers bear the costs for accommodation, air fare and meal, thus resulting in the total unit labor cost of US$250. Assuming 260 working hours per month, the hourly average labor cost amounts to US$0.96, which is nearly double to India and Pakistan, and also equivalent to Malaysia where labor cost substantially increased in recent years. It should be noted, however, that most of expatriate workers in Oman are highly skilled and productive, thus difference in virtual labor costs seem to be smaller than it appears.

Hourly Labour Cost in Textile Industry

(Unit:US$)

	Brazil	Egypt	India	Turkey	Portugal	Italy	Korea	Malaysia	Pakistan	Greek
1991	1.53	0.43	0.55	3.12	3.17	17.31	3.60	0.95	0.38	5.75
1993	1.46	0.57	0.56	4.44	3.70	16.20	3.66	1.18	0.44	7.13

Source: ITMF Country Statement 1993
Note: This cost includes fringe benefit and social charges

Traditionally, the apparel industry has an advantage in countries having low-cost labor force because of its labor-intensive nature. International competitiveness, however, is governed not only by the labor cost but also by numerous other factors, including production management, (quality and delivery control, etc.) ease in the procurement of imported materials, and availability of low-interest loans for working funds. In the low value added garments which are the main products produced in Oman, however, Oman is situated in disadvantage because of competition with those produced in Bangladesh and Pakistan which have lower labor costs. Alternatively, they can improve competitiveness of their products by raising productivity with mechanization, as well as diversifying towards higher value-added garments. The production cost structure in the Oman apparel industry broadly consists of 70% for materials cost and 30% for processing cost. Labor cost accounts for approximately 65% of the processing cost (20% of the production cost). (See Table A1-3-1)

In addition to productivity improvement and product diversification, marketing efforts are important. Since exports to the US market are not likely to grow further due to the import quota, future growth of Oman garment exports cannot be expected, unless efforts are made on marketing and product development while targeting other markets. A primary target should be the EC market that demands high-grade products compared to the US, and thus this marketing strategy requires the production of high value-added products.

Specifically, the apparel industry must work toward improvement in the following areas in order to produce high value-added products.

(1) Mechanization

At present, the industry largely relies on manual operation in most of processes, except for sewing machines. While it is difficult to promote complete mechanization in the near future in view of a relatively small production scale of the manufacturers operating at present, innovative approaches such as the sharing of machinery by several companies in selected processes can be taken to achieve cost reduction and quality improvement.

(2) Use of skilled workers capable of performing advanced work

High value-added products involve an increasing number of production steps with complicated work procedures. Experienced and skilled workers are also required to meet such production process.

(3) Quality control/process control

As the work process becomes complex, a need arises for total quality control and production management capabilities to cover different production steps, in addition to quality check on individual products, thereby ensuring the improvement of work efficiency and reduction of material loss. For this purpose, the middle-class management ability to handle small-lot production in large varieties needs to be developed.

(4) Procurement and control of raw materials

Production of high-grade products in a wider variety entails timely imports of various fabrics and accessories. Again, personnel having sufficient know-how and experience is required to handle materials procurement, together with adequate funds for procurement to meet increased inventories.

In Oman, human resources that meet the above requirements are not readily available locally, but can be recruited from other countries. Capital investment for mechanization is encouraged with the availability of low interest loans, and exemption from import duties on machinery and raw materials, producing sizable benefits. As mentioned earlier, the work sharing among different makers and the establishment of common service facilities should be considered to overcome the current obstacle of modernizing the industry dominated by small enterprises. If the obstacle can be cleared, the country offers a major advantage with liberalized government control on exports and imports. In addition, there is a very low risk of delay in delivery due to labor dispute and natural disaster, or of loss or damage to products on transportation, supported with well-developed infrastructure, so that the industry can meet flexible and short delivery schedule once other resources are mobilized.

One product area where the country's comparative advantages can be maximized to compensate for relatively high labor cost is the production of high-grade knitwear for exports. Knitwear production is highly suitable for mechanization even in a small scale production, and can serve as a model case for modernization of the apparel industry. Japanese examples in Table A1-3-1 clearly show capital intensive nature of the knitwear industry compared to other apparel products.

Note that training of designers is also critical to export-led growth of the apparel industry, but it should be secondary in the modernization process.

3.2.4 Government promotion and support

Clearly, production and exports of high value-added garments will require improvement in a variety of areas, some of which go beyond self-help efforts of individual companies. Effective government support is essential in supplementing individual efforts, particularly in the following areas.

(1) Promotion of automation and mechanization

The government can play an active role in encouraging investment in the areas of automation and mechanization in the form of public assistance and incentive, including the use of ODB loans and exemption of from income tax for a certain period of time.

(2) Establishment of the flexible production system for small lot production and short delivery

High-grade apparel products are sensitive to the rapidly changing fashion trends and are generally supplied in small quantities within a short delivery period. The flexible production system is essential in meeting the highly demanding market. In addition to process modernization and human resource development, it is important to build up appropriate production management system commonly applicable to the industry by means of developing industry-wide operation manuals with assistance of consultants from countries with the advanced apparel industry.

(3) Collection of market information

Market study and research hold the key to the success in the high-end apparel industry. As it is beyond the ability of individual companies, however, government support is highly useful to collect latest information.

(4) Promotion of resource sharing among manufacturers

Restructuring of the apparel industry is highly desirable to secure much-needed productivity improvement. Without it, mechanization cannot be promoted. The government may take leadership in promoting the development of common service facilities and other joint resources, by coordinating efforts and solving conflict of interest among individual companies.

3.2.5 Export markets for apparel products

(1) EC

Imports of apparel products and accessories by the EC as a whole totaled US$63.6 billion in 1992 according to OECD statistics, far exceeding the imports in US amounting to US$33.0 billion. In EC, intra-community trade shares majority, account for 55% of total. Major imports from non-EC countries, according to 1989 data, are Turkey (US$2.1 billion), Morocco (US$900 million), Tunisia (US$800 million), India (US$1 billion), China (US$1.4 billion), Hong Kong (US$3 billion), and South Korea (US$1.4 billion). In the Middle East, Israel exports US$250 million worth of garments to the EC.

By item, major portions of the EC's apparel imports are jerseys, pullovers and trousers, which import values are on the rise. Men's shirts also increase gradually, while skirts and suits remain flat.(See Table A1-3-2)

Major knitwear products imported by the EC are sportswear, leisure wear, fashionable wear, and underwear. Portugal and Greece are major exporting countries, but their advantages as low-cost subcontractors are diminishing due to the rise in wage. Apparel manufacturers in these countries are also losing competitiveness due to obsolete machinery they are using. As a result, EC customers are increasingly finding new subcontractors. Outside the EC, Turkey – one of major exporters – is facing deteriorating competitiveness due to the aging of production equipment and the rapid increase in labor cost. These provide a major opportunity for Oman to enter the EC market.

(2) The United States

The US imported US$33.0 billion worth of garments and accessories in 1992. US apparel imports have been steadily increasing from US$23.1 billion in 1988 according to OECD statistics. A majority of imports comes from China, Taiwan, Hong Kong, and South Korea, but they are losing share due to import quota under the MFA. They are replaced with ASEAN countries as well as Caribbean countries. In particular, Caribbean countries are establishing themselves as the apparel production base for the US by taking advantage of the most favorable nation treatment and are expected to boost share further as they attract investment from the Far East.

The value of imports remains mostly unchanged across all the products in the past few years. Jerseys and pullovers are largest in import value, followed by trousers, blouses, and men's shirts.

(3) Japan

As Japan's imports of textile products are shifting from raw materials to final products, the imports of garments and other textile products are rapidly increasing in share. Nevertheless, the value of imports is fairly small compared to the US and the EC. China and South Korea are major exporters to Japan with a combined share of more than 60% of the country's total apparel imports. Recently, however, South Korea is losing share in terms of volume to China, the US, India, and Thailand. On a per value basis, the third largest exporter to Japan is the US, followed by Italy and Thailand. Imports from the US and the EC account for 22% in value, compared to a mere 7% in weight.

All these circumstances point to a good opportunity for Oman to enter the EC market. Logically, the next step is to study and analyze apparel exports by rivaling Mediterranean countries identifying marketing channels.

Table A1-3-1 Average Cost of Production in Garment Industry

	Knit Maker (Thousand Yen)		Apparel Maker (Thousand Yen)		Garment Factory in Oman (Estimate)
Raw Materials	1,192,042	45%	58,275	14%	60%–70%
Lobour cost	939,516	36%	241,996	59%	20%–25%
Depriciation	66,013	3%	7,529	2%	2%–4%
Rent	10,698	0.4%	4,482	1%	2%–3%
Insurance,Utilities and other	121,293	5%	22,367	5%	10%–15%
Sales and Administration	306,684	12%	72,461	18%	
Total cost	2,636,246	100%	407,110	100%	
Value of machine & equipment per workers	1,384		330		

Source: Production Cost Index for SMI & JICA Study Team

Table A1-3-2 Import of Apparel Goods by Country/Area

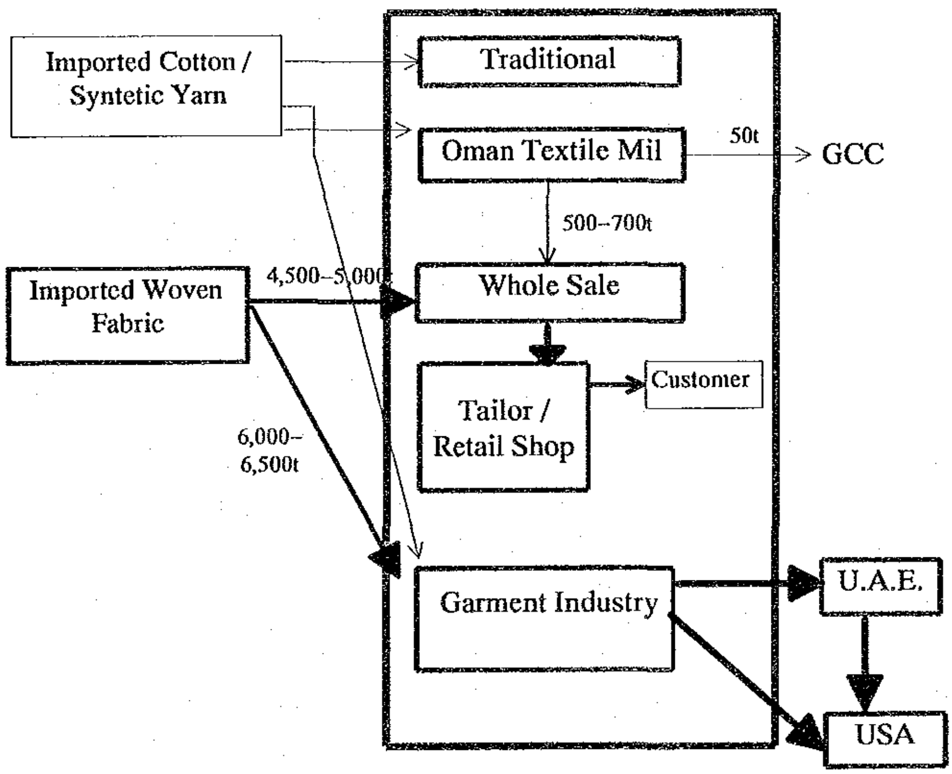
(Unit: US$'000)

Country/Area	Commodities	1987	1988	1989	1990	1991
EEC	Blouses	1,318,939	1,524,113	1,838,651	2,562,108	2,785,988
	Coats and Jackets	1,536,881	1,943,411	1,927,629	2,347,737	2,806,784
	Dresses	843,943	825,370	765,060	858,560	928,575
	Jackets,Blazers ETC	651,089	965,273	992,071	1,240,747	1,414,206
	Jerseys,Pullovers ETC	5,167,484	4,945,318	4,945,318	6,144,525	7,324,597
	Mens Shirts	1,626,557	1,916,913	2,109,783	2,898,700	3,307,086
	Skirts	1,092,138	1,200,116	1,246,986	1,590,242	1,581,732
	Suit	684,565	651,356	698,205	901,117	850,482
	Trousers,Breeches,ETC	2,839,354	2,911,319	3,197,359	4,616,453	4,986,582
	Womens Dresses ETC	1,509,094	868,953	695,259	833,563	975,590
EEC Total	(*)	17,270,044	17,752,142	18,416,321	23,993,752	26,961,622
Japan	Blouses	113,786	198,547	295,096	326,767	329,171
	Coats and Jackets	229,784	244,182	371,481	371,384	424,756
	Dresses	55,851	104,876	111,339	102,268	144,713
	Jackets,Blazers ETC	424,763	203,732	182,349	155,937	150,545
	Jerseys,Pullovers ETC	911,458	1,399,769	1,650,757	1,489,969	1,662,303
	Mens Shirts	150,636	297,455	456,419	457,622	491,492
	Skirts	65,920	117,748	155,743	197,976	219,823
	Suit	37,857	68,920	167,642	202,908	198,447
	Trousers,Breeches,ETC	145,237	257,194	361,012	351,538	434,075
	Womens Dresses ETC	60,594	84,080	90,277	99,046	102,407
Japan Total	(*)	2,195,886	2,976,503	3,842,115	3,755,415	4,157,732
USA	Blouses	1,464,271	1,478,534	1,810,780	1,919,106	1,952,074
	Coats and Jackets	905,712	913,111	691,734	785,055	921,629
	Dresses	571,467	599,719	713,877	780,318	746,163
	Jackets,Blazers ETC	199,631	219,339	236,076	207,885	248,574
	Jerseys,Pullovers ETC	1,972,716	1,802,347	4,656,148	4,461,722	4,483,822
	Mens Shirts	1,485,287	1,565,347	1,763,926	1,773,685	1,870,932
	Skirts	625,378	541,462	660,412	667,930	651,735
	Suit	253,509	302,996	356,099	313,448	328,354
	Trousers,Breeches,ETC	1,343,266	1,463,680	1,909,435	2,110,839	2,225,755
	Womens Dresses ETC	383,647	341,338	428,279	433,869	403,868
USA Total	(*)	9,204,884	9,227,873	13,226,766	13,453,857	13,832,906
World	Blouses	3,709,888	4,101,917	5,037,307	6,298,838	6,762,446
	Coats and Jackets	3,625,320	4,199,136	4,137,307	4,795,384	5,698,310
	Dresses	2,679,326	2,422,441	2,369,052	2,457,705	2,589,997
	Jackets,Blazers ETC	2,053,302	2,180,676	2,252,404	2,465,006	2,788,366
	Jerseys,Pullovers ETC	11,128,620	11,918,963	14,670,975	15,468,736	17,579,157
	Mens Shirts	4,637,551	5,281,110	5,941,725	6,834,634	7,799,567
	Skirts	2,399,825	2,549,291	2,782,014	3,256,486	3,257,766
	Suit	1,692,004	1,658,141	1,725,857	1,836,757	1,915,307
	Trousers,Breeches,ETC	6,245,809	6,502,228	7,547,583	9,274,198	10,300,848
	Womens Dresses ETC	2,674,564	1,980,031	1,794,195	1,867,115	2,107,723
World Total	(*)	40,846,209	42,793,934	48,258,419	54,554,859	60,799,487

Note: (*) Total of major apparel products

Source: UN International Trade Statistics Yearbook

Figure A1-3-1 Flow of Yarn and Fabric



Source: JICA Study Team estimate

4 Non-metallic Mineral Product Industry

4.1 General

In this sector, a total of 1,142 establishments are registered, making it the largest in the manufacturing sector. About 959 establishments (85% of total) are small enterprises having capital of less than RO.25,000. On the other hand, there are 89 large enterprises (8%) with capital of RO.100,000.

This sector consists of the following 5 subsectors:

(1) Pottery, china, and earthware (sector code: 3610)
(2) Glass (sector code: 3620)
(3) Structural clay (sector code: 3691)
(4) Cement, lime & plaster (sector code: 3692)
(5) Other non-metallic mineral products (sector code: 3699)

In "other non-metallic mineral products" subsector, there are 1,118 establishments that account for 98% of total, including 7% large enterprises and 85% small enterprises. As will be discussed later, a wide range of industries are subsumed in this subsector.

No enterprise is registered in the pottery subsector.

4.2 Current Status by Subsector

4.2.1 Glass

In the subsector, 18 establishments are registered. Of total, 9 establishments are located in Muscat, 6 in Al Batinah, 2 in Dhofar, and 1 in A'Sharqiya. Geographically, the subsector is classified as a market-oriented industry. Size distribution is fairly even, without much variation among regions.

There are 5 large enterprises having capital of RO.100,000 or more, and 4 of which manufacture fiber glass products (FRP or FRC), and only one produces etched glass. There is no establishment supplying glass materials. Since it is not likely for relatively small enterprises to produce glass materials, most of enterprises in the subsector seem to be engaged in processing of glass fiber products or production of small glass products.

The processing of glass fiber products is mainly done in the form of manual re-coating to produce bath tubs and water tanks. These products are not suitable for long-distance transportation, so that they are supplied to meet demand in a relatively limited area. In fact, the present level of demand does not favor volume nor automated production

An enterprise is supplying large FRP products for store decoration of fast food chains.

A large enterprise in Muscat, registered in other subsector, has entered the fiber glass processing business as part of its diversification efforts. The company originally started as a manufacturer of asbestos and cement products, and has recently entered the FRP business. It is now producing water tanks, bath tabs, molded animals for outdoor decoration, and boats under license from a Japanese company. It also supplies FRC materials for large buildings such as mosque domes. At present, the company's market is limited within the country (in particular, the license agreement prohibits exports of boats).

Another enterprise, considered to be classified into this subsector, offers unique products. The company, although not very large in size, manufactures sandblasted or chemically etched products, stained glass using the traditional method, and imitation stained glass for building decoration that uses resin colored glass employing technology licensed by a Japanese company. (Note that the company seems to be different from the above-mentioned etched glass manufacturer.) In particular, the company is producing fairly large stained glass products, which are exported to the GCCs. All in all, this is a business offering highly artistic and high-value added products.

Principal glass materials consumed by the subsector are all imported, and so are resin materials for FRP production. Resin for coloring the imitation stained glass is required to be imported from its licenser.

Oman does not produce glass materials. Domestic demand for sheet glass has not reached critical mass that supports domestic production. 3,000 tons were imported in 1992.

Rapid increase in consumption of non-alcoholic beverage in Oman in recent year spurs demand for glass bottles, which are all imported at present. According to the 1992 trade statistics, 18,000 tons of glass bottles (equivalent to 90 million bottles assuming that each weighs 200g) were imported. The current estimate of consumption ranges between 120 - 130 million bottles, with the highest level over 200 million bottles. Thus, domestic consumption seems to have reached a sufficient level enough to support local production.

In fact, partly encouraged by discovery of quality silica sand resources in the country, several companies have already formed a group that considers a joint venture for glass bottle production. Market environment is not totally favorable for Oman, however, as price wars are heating up in importing countries and a glass bottle plant still under construction in the UAE. Thus, production in Oman will face intensive competition from the beginning.

As seen in the previous example, large enterprises manufacturing glass fiber products seem to have the ability to further diversify products in response to increasingly diverse domestic market in the future.

4.2.2 Structural clay

In this subsector, only one establishment is registered. It has capital of RO.25,000 or less and is located in A'Dakhliya, with business details being unknown.

4.2.3 Cement, lime, and plaster

There are 5 establishments registered in this subsector. Four of them are large enterprises with capital of RO.100,000 or larger, two cement manufacturers located each in Muscat and Dhofar, and one lime manufacturer in Muscat. The other establishment is much smaller, with capital of less than RO.25,000, and is located in Muscat. Other details are not known.

Cement production, as a strategic industry has been considered relatively early partly because of abundant supply of lime stone in the country, and because cement is an essential construction material in economic development. Today, two cement companies operate each in northern and southern parts of the country. The principal material, gypsum, is produced locally, while other sub-materials are imported. Basically, domestic cement production meets domestic demand. If a deficit occurs, cement or clinker is imported from the UAE. Surplus cement is mainly exported to the UAE or sold to international cement traders. In addition, an establishment in Dhofar exports cement to Yemen almost on a permanent basis.

As for lime production, one quick lime manufacturer and one slacked lime manufacturer are registered. A company in Quriyat, however, produces both quick lime and slacked lime within the same site and has stated that there is no competitor in the country. The company uses some portions of produced quick lime for production of slacked lime shipped to the domestic market. Then it exports 65% of the remaining amount to the UAE, and uses the rest for brick production in another plant nearby. The lime plant's capacity can still be fully utilized, and the company is considering production of lime-based products, to complement demand-led production boost in future.

While there seems no plaster manufacturer, slacked lime produced by the above-mentioned manufacturer is mainly used for plaster and mortar according to the information from the manufacturer.

4.2.4 Pottery

No establishment is registered as a pottery maker. Nevertheless, there are home factories producing pottery using traditional production techniques in certain areas. In one site, a workshop is operated under supervision of the Ministry of National Heritage and Culture for the purpose of transferring and promoting traditional pottery arts and techniques by bringing machinery and experts from China. As a result, previously unglazed pottery products are now glazed, and diverse types and designs are created.

While such efforts are difficult to be converged into a "manufacturing industry" in the short run, they are desirable from a long-term perspective, particularly in light of the fact that availability of quality kaolin resources has been ascertained in the country.

4.2.5 *Other non-metallic mineral products*

This subsector has 1,118 registered establishments, the largest subsector in the country's manufacturing industry in number..

Naturally, the subsector contains varying sizes of enterprises. 954 out of 1,118 (85%) establishments are small enterprises of capital less than RO.25,000, while large enterprises of RO.100,000 or larger in capital amount to 80 (7%). As a result, medium-sized enterprises are relatively small in number.

Geographically, a large concentration is seen in inland areas; 99 in A'Dhahira and 115 in A'Dakhliya, with a combined total accounting for 19% of total.

Major products in this subsector are diverse in type, including coarse and fine aggregates for concrete production, concrete blocks and other cement products, and tiles, as well as quarrying and processing of marble and other natural stone materials. Essentially, these industries are characterized as suppliers of construction materials utilizing locally available mineral resources, but each of them show unique structure and character.

74 enterprises have capital of RO.100,000 or larger (large enterprises) and 57 enterprises having capital between RO.25,000 and RO.75,000 (medium-sized enterprises). The following is analysis of these two groups.

Aggregate and sand manufacturers represent the most number of large enterprises, totaling to 30. They quarry the rough from wadi and rock mountains, and crush and classify it. In fact, there are several enterprises which seem to operate similar businesses, such as crusher products, crushed sands, washed sea sands, making a total of 33 enterprises. Geographically, 8 enterprises (11 if those in similar business are included) are concentrated in Muscat, and 10 are located in the inland area, A'Dhahira , indicating that they prefer to locate near raw material sources (quarries). Also, a very small number of "medium-sized enterprises" (1 in Muscat and 2 in A'Dhahira) suggests that the subsector is classified as capital-intensive industry. At the same time, the field survey reveals a large number of very small quarry producers.

Concrete block manufacturers make a sharp contrast to aggregate and sand manufacturers. Compared to 12 large enterprises (10 in Muscat, 1 in Al Batinah, and 1 in A'Sharqiya), medium-sized enterprises number to 43, and are located in wide areas outside Muscat. This seems to be due from the fact that most of buildings in Oman are made of concrete block, whose production does not require advanced technology or equipment. As a result, the subsector does not always require sizable capital investment and tends to be located near the market.

Ready-mixed concrete makers are mostly large in scale, totaling to 7 enterprises. They are concentrated in heavily populated areas of Muscat and Al Batinah, as well as inland areas of A'Dhahira and A'Dakhliya. It should be noted that there is one unregistered manufacturer in Dhofar, which has diversified into mosaic tile production.

In the tile and mosaic tile industry, there are 9 large enterprises and 6 medium-sized enterprises. Five large enterprises producing tiles are located in Muscat, and those producing mosaic tiles are found in Muscat and Dhofar. Medium-sized enterprises are divided into 2 tile makers (1 in Muscat and 1 in Dhofar), and 4 mosaic tile makers (2 in Muscat, 1 in Al Batinah, and 1 in A'Dhahira). They seem to be market-oriented and do not require large facilities and equipment.

Mosaic tiles are made by using locally available materials - marble tips and powder, aggregates, and cement - as well as imported materials such as white cement. Large enterprises use automated machinery made in Italy, whereas small enterprises and micro-enterprises rely on manual work.

Product specifications vary across regions. 25cm x 25cm tiles are produced in Muscat, and 30cm and 30cm in Dhofar. Production capacity of highly automated large enterprises ranges between 200 and 1,000m^2 daily.

On the other hand, medium and small-sized enterprises have small production capacities and their products are inferior in quality. As a result, they do not directly compete with large enterprises.

Notably, products made in Sohar are shipped to Muscat, but those made in Dhofar are not competitive in Muscat. In fact, marble products made in Muscat find their way to the Dhofar market, mainly because of cost advantage in transportation of marble tips that are produced in Muscat.

No detailed information on tile manufacturers is available. Products seem to be cement– based, not pottery.

Marble and other decorative stone manufacturers quarry and process natural stone materials. There are 4 large enterprises (3 in Muscat and 1 in Al Batinah), and 1 medium–sized enterprise in Muscat. These activities are classified as the market–oriented and capital–intensive.

One large enterprise in Muscat processes imported marble, others cut and polish locally produced marble into tiles (30cm x 30cm) and slabs (larger than tiles, used for stairs of buildings). They depend upon availability of quality raw marble, and their sources include relatively remote quarries.

Three enterprises in Muscat have unique characteristics of their own. The largest enterprise operates 2 production lines with annual capacity of 240,000m^2 and exports 70% of its products. The second one has a production line with 45,000m^2 capacity, which is equipped with computer–controlled advanced machinery, and offers competitive edges in terms of high accuracy and polishing quality. They also supply products to large–scale projects, both government and private.

On the other hand, the third largest enterprise does not have production capacity that can serve large projects, but has competitiveness in color variation. Their products are supplied to buildings constructed by the private sector.

A stone processing company, newly established in Dhofar recently, intends to develop locally available marble and granite to commercial products. However, development of the quarry obtained by the company is prohibited because of its location in "green zone" leaving the company to use raw stone of poor quality available in remote quarries.

There are two large–scale companies, each producing Art Marble Bathset, and Kerbstone , and one medium–scale company producing Kitchen Counter Top , all located in Muscat, which seem to be manufacturing similar products.

Based on the above analysis of the large enterprises and medium–sized enterprises, most of small enterprises with capital of less than RO.25,000 which dominate the subsector in number, seem to produce concrete blocks and other cement and concrete products almost manually. At the same time, many small crushed stone makers are suggested to exist.

Finally, the subsector contains large enterprises specializing in certain specific product categories, which are summarized as follows.

An asbestos cement pipe manufacturer in Muscat: This company was regarded as a pioneer enterprise with the ability to lead the industrialization process at the time of its establishment. The company is the largest asbestos pipe maker in the Gulf area and exports substantial portions of production (valued at RO. 3 million, out of 4 RO. million in total sales) to other GCCs, mainly Abu Dhabi. It is also in the process of business diversification, to venture in plastic pipes (PVC and PE) that will compete with another company in Oman. It also desires to venture into fiber glass products, and large plastic products made by rotational molding.

A baryte manufacturer in Dhofar: The company crushes and pulverizes quartz, bentonite, and limestone, in addition to baryte (all but limestone is imported), to produce drilling mud materials. While the company commands a near-monopoly position, it does not have much international competitiveness, excepting exports to the UAE to meet urgent demand.

Among the ingredient materials, bentonite is demanded for casting mold and is blended with binder as a saleable product. Limestone powder, which is essentially calcium carbonate, can be used for other applications other than drilling mud, if the desired high purity is available.

An eldorado stone manufacturer in Muscat: Eldorado stone is a lightweight artificial stone material for decoration of building exterior, made of various rock powders, white cement, coloring agent, and foaming agent which are mixed with water, molded and baked. Because of highly specialized technology, there is no competitor in the field.

A brick manufacturer in Muscat: The company produces silica-lime bricks by using sand having high silica content, and quick lime produced at its own plant near Quriyat. These are mixed and caused to react by adding water (plus pigments as required), then molded and heated in high pressure steam. Silica-lime bricks are mainly used for building exterior due to its higher cost compared with concrete block as a structural material. There is no competitor within the country.

A gypsum manufacturer in Dhofar: The company is a division of one of the marble manufacturers mentioned in the foregoing section. The company has been a sole supplier of gypsum for domestic cement manufacturers. Recently, however the market is becoming competitive, as a cement manufacturer in the area started its own quarrying of gypsum, and another company obtained a quarrying license of gypsum.

4.3 Future Prospect

The subsector is characterized as an industry relying on local resources which has been driven by vigorous construction activities in the country. This means that its future growth in the domestic market is rather limited. Nevertheless, some of "large enterprises" are expected to diversify themselves, making themselves flexible to meet increasingly various demand in the country, as in the case of the asbestos cement manufacturer and the mosaic tile manufacturer which have grown out of traditional aggregate and ready-mixed concrete businesses.

Also, some may be able to explore the export market in neighboring countries by applying technical and marketing know-how and experience.

Some large marble manufacturers have already started exporting, and other enterprises are boosting production capacity for the purpose. An aggregate supplier has obtained quarrying rights in the UAE and plans to export products.

Finally, there are several construction materials that are not used in the country, but can have a sizable market tapping Oman and other GCCs, if demand is properly spurred. One is gypsum board that has excellent fire resistance properties, insulation effectiveness, and sound insulation performance. Another is rock wool that can be used as an excellent insulation and fire-proof material. At present, several companies already experience growing business of ceiling and partition boards conversion using imported gypsum board and rock wool. High quality gypsum resources and rock suitable for producing rock wool have been identified locally through mineral resource surveys. The use of these construction materials is beneficial in terms of prevention of building fire and saving in electricity for air-conditioning. Also, the presence of good silica sand resources, and availability of locally produced quick lime suggest possible commercialization of such lime-silicate-based construction materials as bricks and boards, etc.

5 Metalworking Industry

5.1 General

SITC classifies the fabricated metal products industry (covering the same types of products as the metalworking industry referred to in this report), according to products, into various subsectors shown in Table A1−5−1.

From the viewpoint of industrial development, the classification of the metalworking industry according to processes involved reflects the actual conditions of the industry. This is because the industry has developed a group of independent and specialized subsectors which have gradually become independent from an originally single process. Major metalworking subsectors generally seen in industrialized countries, as classified by process, are shown in Table A1−5−2.

The number of enterprises in the metalworking industry in Oman by investment size (capital) and region is shown in Table A1−5−1.

550 enterprises are registered in the metalworking industry. Only 37 (7% of total) are relatively large in size (RO. 100,000 or over) while 451 (more than 80%) have a capital of RO.25,000 or smaller.

Generally speaking, larger enterprises (mainly RO.75,000 or larger) have introduced relatively modern machinery and technology and serve the national market as well as the export market. On the other hand, many of smaller enterprises including micro enterprises (RO.50,000 or smaller) are mainly serving local demand in small quantities, and operate in the form of workshop relying on manual work and a limited number of simple machinery.

5.2 Current State of Metalworking Subsectors

5.2.1 Metal furniture, structural metal products, and fabricated metal products

Of 550 enterprises, 507 belong to two subsectors, structural metal products and fabricated metal products by SITC. When 20 enterprises in the metal furniture industry are added, these 3 subsectors account for 96% of total.

Two enterprises in the metal furniture subsector are large in investment size (over RO.100,000), markedly different from remaining 18 companies which have a capital of

RO.25,000 or less. The large companies manufacture beds and chairs made of steel pipes, and office desks and cabinets using steel plates.

The two-tier structure consisting of large corporations and small workshops is also seen in the structural metal products subsector, where 13 enterprises have a capital of RO.100,000 and 122 enterprises RO.25,000 or less. The large enterprises mainly produce building fixtures, including doors, window frames, and handrails, and many supply aluminum products. It should be noted, however, that the category includes boiler manufacturers and welding fabricators, as mentioned later.

Small enterprises and micro-enterprises in the metal furniture subsector also make similar products, such as doors and window frames, and small tanks.

The fabricated metal products subsector supplies product lines similar to those of the structural metal products subsector, under the two-tier structure composed by large enterprises and small enterprises/micro-enterprises. Large suppliers produce wire sheets and fences, nails, and shutters, in addition to fixtures that are also provided by the structural metal suppliers. In addition, a food manufacturer is also included in the category, producing food containers. Also, there is a nonferrous metal foundry, in which details are not known.

Enterprises classified into the metal furniture, structural steel and fabricated metal products subsectors import general steel or aluminum materials and fabricate them into products through simple sheet metal working, welding, and painting (machining for some products). Their products generally involve a low level of local processing, and material costs account for 65% - 70% of total.

These subsectors principally serve the construction and related industries.

5.2.2 Machinery

The number of enterprises classified in the machinery subsectors is very small compared to the above three subsectors, ranging only between 1 and 3.

In the engines and turbines subsector, there is only one company which manufactures water pumps under the license of a foreign company. The company obtains motors and other major components, special pipes and cables from its licenser, imports general materials, and is responsible for the machining of structural materials, sheet metal working, assembly and painting of panels.

There are three companies registered in the subsector classified as other industry, which includes a company manufacturing refrigerator cars, special air-conditionering cars and ice machines by using refrigerating machines which the company import from abroad.

In the industrial electric machinery subsector three companies were registered, among which a company manufactures switch boards, feeder pillars, switch fuse units, etc.

There are two companies registered in the electric appliances, consisting of a company manufacturing electric heaters and another assembling air conditioners.

There are three companies in the electrical industrial machinery subsector, and one company produces automotive batteries under the license from a US company. It is the only company in Oman that supplies automotive batteries. Another company produces PVC cables by importing general materials and using special production equipment.

Two companies are classified in the motor vehicles subsector, and one produces automotive radiators for the replacement equipment market (REM). The company mostly uses general materials including copper and brass sheets, and the material cost accounts for only 15% of the total production cost. Most of production equipment is customized to provide several hundred types of products in relatively small quantities. At the same time, the process depends heavily on skilled workers.

Enterprises registered in each subsector normally hold 60% - 85% share of domestic demand accounting for their business base, and export 30% - 45% of total production to the GCCs. In Oman, they have to compete with products imported from the GCC, and they generally maintain market share in the given range by offering quality products. Also, many of them use off-the-shelf materials for processing, making raw material cost very small in percentage from total cost. As widely seen in metalworking industries in the country, these enterprises are not much automated to attain production flexibility in response to a small market size. Rather, they adjust production by using skilled workers in various parts of the entire process. As a result, they generally attain a high level of value added. At the same time, they often use specialized machinery in some processes. In such a case, their ability to diverse into other products will be limited.

5.2.3 Other metal products and machinery

In addition to the above, 2 small companies (a capital of RO.25,000 or less) belong to the cutlery, hand tool and hardware subsector, and 1 medium-sized company (RO. 25,000 - 50,000) to the agricultural machinery subsector. In the special industrial machinery subsector, there is one large company (capital of over RO.100,000) producing block manufacturing equipment and one medium-sized company (RO.25,000 - 50,000). In the other machinery subsector, there are two companies having a capital of over RO.100,000 and RO.75,000 each, whose products are not known. Three companies are registered in the shipbuilding and repairing subsector. Two have a capital of RO.50,000 each and 1 RO.25,000. All of them are located in Sur and seem to produce wood ships, rather than metal ones. Note that another company in the motor vehicle subsector manufactures truck bodies. Detailed data are not known for these companies.

5.3 Imports of Metalworking Products and a Future Outlook for the Metalworking Industry

5.3.1 Raw materials and base metals

In 1992, imports of iron and steel, such as pig iron, steel, hoop steel, bar steel, shape steel, and ingot amounted to RO. 24.3 million (170,000 tons). This volume is far from justifying a local production. On the other hand, establishing a steel stock center having distribution and simple processing capabilities seems to be important for future growth of the metalworking industry. The center can also be used as an export base to meet steel demand in the GCCs and other neighboring countries. In this case, infrastructure needs to be improved, including excellent port and harbor facilities including efficient loading and unloading work, and streamlined export and import procedures.

5.3.2 Secondary steel materials

Imports of steel materials such as pipes and wires, components such as springs and pipe fittings, and cast and forged products totaled RO. 54 million , or 117,000 tons in 1992. Of total, steel pipes and casings amounted to RO. 35 million, or 88,000 tons. However, their minimum production level is enough to enjoy the economy of scale far above the current consumption level.

The second largest subsector comprise tanks and other heavy items, amounting to RO. 8.2 million or 13,600 tons.

5.3.3 Boilers, engines, pumps and parts

The category recording the largest import is agricultural machinery and parts, totaling RO. 59 million or 12,300 tons (not including some mowing machines which are recorded on a per unit basis). The category covers 18 H.S. 5- digit and 6-digit industries. As mentioned in steel materials, this is the area where construction of a distribution and repair center can be contemplated.

The second largest segment are motors, engines, turbines, and pumps, amounting to

RO. 23.5 million or 4,000 tons. It should be noted, however, that this category encompasses 34 H.S. 6-digit industries, and each components does not show particularly a large size.

Then, imports of fans and compressors, and their parts amount to RO. 17.9 million (tonnage data are not available, as some of them are recorded on a per unit basis). Of total, air-conditioners and parts account for RO. 16.5 million or 90,000 units, and are considered to be one of a primary candidates for local production or assembly.

Finally, non-metal ore quarrying and processing machinery and parts amount to RO. 16 million. On a per volume basis, however, they are not very significant (800 tons).

5.3.4 Electronics and electrical components and parts

General electric parts, such as switches, plugs, and lamp holders, show the highest share of total imports of electronics and electrical components and parts, totaling RO. 14.8 million or 3,800 tons. Local consumption of these parts is expected to increase further, so that they are considered as a prospective area of local production.

The second largest segment are broadcasting equipment, radio receivers, and television sets, amounting to RO. 27.3 million. In particular, color TVs – 130,000 sets imported in 1992 – seem to approach a level of local production, if exports to the GCCs are taken into account.

The next largest segment are telephones and communications equipment, totaling RO. 11.4 million. Of total, wire communication equipment and parts account for RO. 9.6 million. However, this amount seems substantial because it is related to a certain project, as the value of imports dropped to RO. 3 million in 1991 following that.

5.3.5 Motor vehicles and parts

Imports of motor vehicles and parts in 1992 reached RO. 331 million, accounting for *more than 40% of total metal and machinery imports.*

Motor vehicle imports consist of 46,400 passenger cars, 3,100 vehicles for commercial and industrial uses, and 2,700 vehicles for public transportation, with a combined total of 268 million Rials. On the other hand, imports of automotive parts totaled RO. 56.3 million or 14,800 tons.

While the present level of demand is still too small to consider local production, on a per unit basis on the other hand, the country seems to have reached a market size to make CKD production feasible, unless demand is not much diverse.

Local production of automotive parts seems to be feasible on a total volume basis, but the current level of variation among makers as well as individual models, together with the general lack of interchange ability, indicates an unfavorable prospect. One realistic approach is to consider a system flexible for producing a variety of product mix in a small lot, for standardized parts as in the case of battery and radiators, under the assumption that they will also be supplied to the GCCs.

5.4 Current State of Metalworking Subsectors by Work Process and Future Outlook

5.4.1 Product development type enterprises

As mentioned earlier, in Oman, relatively large enterprises in the metalworking industry are of product development type according to the classification by work process (Table A1–5–2). These companies have the ability to plan and design their own products, albeit not at a sophisticated level, or produce proprietary products with designs introduced from outside sources. They mostly use generally available materials, machine elements, and components (such as motors). The use of customized parts is limited to production under the licensing agreement with foreign companies. Similarly, most of production equipment is of general type used for relatively simple machining, while the use of special machinery is highly limited. Theoretically, as metalworking enterprises manufacture increasingly diverse product lines and adopt a complex production process, they transfer some of processes to outside subcontractors to start horizontal division of labor. However, most of companies in Oman use simple production lines, and there is no supporting industry specializing in metalworking processes on a contract basis. Thus, in–house machining and assembly is the general norm.

Small enterprises and micro–enterprises follow the same business practice of producing final products all by themselves, differing only in size of order. Thus, subcontracting certain metalworking process is not usual.

5.4.2 Equipment–intensive type enterprises

The product development type enterprises must have high levels of technology in each process in order to develop new products on a continuous basis and to maintain high quality levels. This can generally be accomplished by manufacturers specializing in specific processes with required equipment, manpower, and know–how. However, there is no move toward the emergence of support industries in the country for various reasons, e.g., the market is too small to achieve an economy of scale.

At present, there is a large enterprise specialized in boiler making and welding, while there are a few small enterprises/micro-enterprises.

The boiler making and welding process cuts and joins heavy steel plates to manufacture equipment installation bases and tanks. Companies undertaking such process range from large plant makers to construction material makers.

In Oman, there is sizable demand for boiler making and welding works, including PDO and other plants, gas stations, and tank lorries. However, large plant construction projects face intensive competition with foreign contractors.

For an industry focusing on customized production based on individual skills, securing skilled workers is important than the introduction of advanced technology. At present, most of companies rely on foreign engineers and workers. On the other hand, there is a small number of indigenous workers who work as trainees and they seem to quit soon before obtaining skills. Thus, it is difficult to foster indigenous skilled labor force.

As seen in the product development type enterprises, the processing companies specialized in boiler making and welding have their own machining lines and manufacture all components and parts, including small and volume products.

The steel metal working process involves the cutting, bending, and welding of 2.5mm or thinner steel plates by using a variety of machine tools, including shearing machines, punching machines, presses, and bending machines, to manufacture housings and chassis of machinery and equipment. As the magnitude of order is dominated by small lots ranging from 5 to 10, small enterprises and micro-enterprises account for major portions of the industry.

As mentioned earlier, large "product development type" enterprises in Oman have their own sheet metal working processes. On the other hand, small enterprises specialized in manual working of thin plates seem to serve small local demand, but none of them seems to have the ability to do jobs for the large enterprises.

The press work companies are specialized in die-cutting of steel plates by the press, drawing, and sub-assembly. Also, they manufacture their own dies to some extent.

In Oman, most of components and parts requiring press work are said to be imported. Thus, few product development type enterprises have their own processes. On the other hand, some of enterprises specialized in boiler making and welding have shearing machines, and produce small and volume products by using small punching presses. This clearly reflects the lack of press work enterprises that meets demand.

There is no casting and forging processes commercially operated in the country, excepting small-scale operation that has not been confirmed[1]. The casting process has an advantage in making products of complicated shape with relative ease. On the other hand, the forging process can produce a material with strength and toughness through plastic deformation by heating it at a high temperature, and using the press or hammer. Also, it is capable of forming it into various shapes to eliminate the need for machining.

In Oman, all the products and parts requiring these processes seem to be imported. At the same time, the metalworking subsectors that need the casting and forging processes have not been developed.

It should be noted that the above processes use heavy machinery and equipment, thus requiring a sufficient market size to achieve the economy of scale.

The heat treatment process involves the adjustment of steel hardness and viscosity to improve workability, or the enhancement of product strength, fatigue resistance, and wearing resistance. Heat treatment does not apply to all metal components and parts. Rather it is limited to forged products and special machine parts, which are imported to Oman after heat treatment. Given the small size of the domestic market, the heat treatment process is not likely to establish itself as a separate industry in the country even if local production of automotive metal parts (requiring a process to increase strength) is started.

The coating process is essential for surface protection of most machinery and equipment, and thus it forms an integral part of industrial development. However, the product development type enterprises in Oman have their own coating process as a result of small product size or small production lot, and they do not subcontract the work.

Fabricators which fabricate comparatively large size of tanks and vessels also undertake painting by themselves.

The metal surface treatment process includes electroplating, alumite, and metallikon. In Oman, there is no enterprise specializing in electroplating because the metalworking subsector requiring large amounts of electroplating has not been developed.

Note that the large boiler maker has a galvanizing plant and provides plating services for other companies.

5.4.3 Metalworking type enterprises

The cutting process involves machine cutting of workpieces into required shapes and dimensions at required levels of accuracy. In Oman, the product development type

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[1] One company is registered as the nonferrous metal foundry maker, which details are not known.

enterprises requiring the cutting process have their own, and there is no company specializing in providing a subcontracting service. Note that there are no data on micro-enterprises serving local demand.

The aforementioned boiler maker has its own machining process.

The situation is similar in turning and grinding processes. Note that these processes are owned by enterprises specializing in the cutting work, and there is a limited number of companies specializing in these areas in industrialized countries.

Finally, dies, jig and tools are not produced in Oman. While there is a large number of companies which require them, they still import all of them, including dies for plastic injection molding, gauges, and tools.

5.4.4 Functional type enterprises

There is no company specializing in contract processing and assembly partly because there is a lack of demand for assembly of volume products, and partly because most of the product development type enterprises do their own assembly and processing.

As for production of machine elements (general metal components and parts) which are classified into machined types (bolts, nuts, screw threads, and gears) and press worked types (springs and wires), there is only one company producing (nails) in the country. This subsector cannot have high value added unless it produces highly specialized products. As long as standard products are produced in large quantities for trading companies specializing in parts, profitability can be secured only through process automation and extended operation. Thus, the subsector becomes commercially viable only when there is an industrial concentration manufacturing small and volume products.

Table A1-5-1 Fabricated Metal Products Sub-Sector

Sector Code		Total	Size of Investment (Unit: R.O.)				
			>=100,000	>=75,000 & <100,000	>=50,000 & <75,000	>=25,000 & <50,000	<25,000
3811	Cutlery, hand tool/ hardware	3	0	0	0	0	3
3812	Metal furniture	20	2	0	0	0	18
3813	Structural metal products	157	13	6	9	7	122
3819	Fabricated metal products	350	10	7	10	16	307
3821	Fabricated metal products	1	1	0	0	0	0
3822	Agricultural machinery	1	0	0	0	1	0
3824	Special industrial machinery	2	1	0	0	1	0
3829	Special industrial machinery	3	2	1	0	0	0
3831	Electrical industrial machinery	3	2	0	1	0	0
3833	Electrical appliances	2	2	0	0	0	0
3839	Other electrical appliances	3	2	0	0	1	0
3841	Ship building/ repairing	3	0	0	0	2	1
3843	Motor vehicles	2	2	0	0	0	0
3844	Motorcycles & bicycles						
3800	Fabricated metal products	550	37	14	20	28	451

Source: MCI

Table A1-5-2 Classification of Establishments in Metalworking Subsector by Type of Metalworking Process

Product Development Type	Product manufacturing
Equipment-Intensive Type	Boiler making and welding Plate working Stamping Casting Forging Heat treatment Painting Plating
Machining Type	Machining Dies, jig and tools making
Peripheral Function Type	Plastic processing Printed plate board fabrication Contract processing and assembling Machine element manufacturing Raw materials relating industry Others

ANNEX 2

INTERNATIONAL SUPPLY AND DEMAND TRENDS IN PETROCHEMICAL PRODUCTS

2 International Supply and Demand Trends in Petrochemical Products[1)]

2.1 General

A primary indicator representing general trends in the petrochemical industry is ethylene which is the most widely produced and consumed primary hydrocarbon product, and serves as a basic building block for varieties of petrochemical products. In addition to the fact that ethylene produces diverse types of derivatives in large quantities, it is highly sensitive to actual demand because its property – in gaseous form at normal temperature – makes storage and transportation very difficult and costly. Other petrochemical product families include propylene and its derivatives, C_4, and aromatics.

Ethylene is produced from ethane, propane, butane, naphtha, or gas oil. Ethylene produced by heat cracking ethane accounts for one–fourth of the total. In the dominant manufacturing processes, naphtha cracking, various co–products such as propylene, C_4, and aromatics are also produced together with ethylene. In fact, the petrochemical industry's business performance is characterized by a combination of profit and loss from a wide range of products. Thus, while the project to produce ethylene from cracking of ethane, and its 100% derivative – polyethylene – can be evaluated relatively easily, forecast for the development of the general petrochemical industry becomes very complex.

Petrochemical industries in industrialized countries experienced serious recession in 1983 and 1984. After the partial scrapping and shutdown of excess capacities, the industry was blessed by sharp declines in oil prices due to a global glut. Strong economic growth throughout the world spurred by plummeting prices of raw materials and low energy costs has brought about a sharp upturn of the petrochemical market. Then, the major capacity buildup fueled by boom times in 1987 through 1990, including aggressive expansion by Korean and other makers based on an optimistic outlook, has reversed supply and demand balance, which continues until now. In the meantime, markets in Asian countries continue robust growth, compared to recession–ridden industrialized economies, and are expected to serve as a major source of growth for petrochemical demand. (Table A2–1)

2.2 Ethylene

The world ethylene production capacity is expected to increase by 19 million tons

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1) The analysis is based on data published by the Japanese government (Industrial Structure Council), IBRD and other sources.

from 73 million tons in 1992 to 92 million tons in 1997. Major capacity expansion includes 3.2 million tons in the Middle East, 2.5 million tons in Western European, and 4.3 million tons in Asia. On the other hand, demand will grow by 2% in the US and Europe, while Asia, particularly Southeast Asia will record a 9% increase. In the US and Europe, capacity growth will exceed demand leading to lower operating rates below 90%. In Asia, despite the significant increase in production capacity, high growth of demand for derivatives in Southeast Asia, accompanied by the increase in the respective derivative production capacities, will result in continued tight supply. However, if ethylene plants planned or constructed in ASEAN countries come on stream as scheduled, supply will catch up with demand toward 1997. (Table A2-2)

2.3 Polyethylene

2.3.1 LDPE (Low-density Polyethylene) and LLDPE (Linear Low-density Polyethylene)

Polyethylene, particularly LDPE, is the petrochemical produced in the largest quantity and accounts for around 40% of ethylene consumption. It has been a major driving force for growth of the petrochemical industry up until today. It has been originally produced through polymerization process under high-pressure, then the commercialization of linear low-density polyethylene (LLDPE) has decreased a process pressure. Recently, a process capable of producing all types of polyethylene has been reportedly developed.

Polyethylene production is forecasted to grow at 5.4% annually between 1992 and 1997, while the capacity utilization rate will range between 75% and 80%. In particular, strong growth is expected in Singapore and China, 19% and 16% respectively. Robust demand growth will continue in Malaysia, Indonesia, Thailand, and other ASEAN countries, in the range between 7% and 10%. In contrast, industrialized countries will have a high share in the global market, particularly Western Europe, but will experience slow growth (4.2%) during the same period, falling below production growth. As a result, the operating rate will remain at 75%/80% between 1992 and 1997, creating a surplus of 1 million - 2 million tons annually. Meanwhile, volume of exports from traditional producers in North America, the Middle East, and Western Europe to Asia and Latin American will continue. (Table A2-3)

2.3.2 HDPE (High-density Polyethylene)

The production capacity will rise at an annual 4%, from 13.8 million tons in 1992 to a slightly less than 15 million tons in 1997. Supported by healthy demand growth, the operating rate will remain at around 90% between 1992 and 1997, and production will grow 5.0% annually. Demand will be up by 4.6%, with packaging materials and general merchandise being major contributors. By region, 800,000 tons will be added in Asia, 560,000 tons in Western Europe, 870,000 tons in North America, and 310,000 tons in Latin America. High growth rates are seen in Asia (6.0%) and Latin America (7%), compared to the world average of 4.6%.

Overall, a surplus will continue to increase, with the exact amount depending upon a LLDPE/HDPE production balance at swing plants. The present forecast indicates that the surplus will exceed 1 million tons in 1997, notably large in the Middle East and North America. Asia, despite a higher self-sufficiency rate, will remain as a net importing region, amounting to 180,000 tons in 1997. The traditional global flow of HDPE trade will prevail, from North America, South Korea, Singapore, and the Middle East, to Asia (led by China) and Latin America. (Table A2-3)

2.4 Styrene Monomer

The production capacity will build up at an annual rate of 5% between 1992 and 1997, from 17.22 million tons to 21.93 million tons in 1997 respectively. Production will grow at 3.8% with an average operating rate of 80%, reaching 17.5 million tons in 1997. Demand will remain firm due to the addition of PS/ABS capacities in Asia, and grow at 3.7% keeping pace with production to maintain the supply and demand balance. The global trade pattern continues to be dominated by the traditional flow from North America and the Middle East to Asia, including Taiwan, Hong Kong, and China which are restrained by the shortage of feed stocks. South Korea turned into a net exporter in 1992, Indonesia in 1994, and Singapore, Malaysia, and Thailand in 1996. (Table A2-4)

2.5 Polyvinyl Chloride

The worldwide production capacity will grow moderately at an average of 1.2% from 23.55 million tons in 1992 to 25.4 million tons in 1997. Production will increase by 3%, and the capacity utilization rate will gradually rise to around 86% in 1997. Demand, becoming saturated in industrialized countries, will grow at 3.2% annually. As a result, a surplus of 1 million tons will be seen until 1995, then the supply and demand balance lead to a shortage side thereafter. Globally, PVC is largely traded in the form of intermediate feed stocks - EDC/VCM. Major importers are South Korea, Taiwan, and Japan, while exporters are North America and Latin America. (Table A2-5)

2.6 Ethylene Glycol

If the capacity increases up to 1997 progresses as planned, the production capacity will grow at an annual 6%, a 40% increase between 1992 and 1997 to reach 12.11 million tons. Production will expand by 6.6% during the same period, and the operating rate will remain at around 75% as the capacity continues to build up. Demand for polyester fiber production, which is saturating in industrialized countries, will grow strongly in developing countries. The world average growth rate will be around 5%. As a result, a net surplus over 1 million tons is likely to occur in 1997, which may force the industry to postpone or scale down capacity expansion. The current world trade pattern – with major exporters being Canada and the Middle East, and importers Asia and Western Europe – will continue in the future. (Table A2–6)

2.7 Propylene

Based on construction plans announced by major producing countries , the world propylene production capacity will record an annual average growth rate of 3.5%, from 41,390,000 tons in 1992. In Asia, a number of additional naphtha cracking processes are planned to boost the production capacity by 20% between 1992 and 1997. Note that a large amount of propylene is recovered from refineries in the US and other countries, in addition to propylene as a by–product of ethylene production, so that the above figure does not represent the actual production capacity.

As a result, propylene production will grow in pace with production of derivatives, at an annual 4.9% worldwide between 1992 and 1997. The operating rate will remain at an nearly 80% level. However, the operating rate of dehydrogenation plants requires periodical monitoring.

On the other hand, demand growth will hover at a 2% level in the US and Europe, in the case of ethylene. In Asia, strong growth at 8% level is expected , as driven by PP production in Southeast Asia. Demand for PP production will record relatively strong growth in Europe and the US, registering a world average of 4.3%.

The supply and demand balance will be governed by operating rates of ethylene plants and composition of ethylene materials. Generally, a deficit will occur in Western Europe, while a surplus will continue in the US. Asia will turn reach a surplus in 1995 and onward as new crackers will come on stream.

World propylene trade will continue to flow to Western Europe, especially the northwestern region, as well as Latin America. Supply sources will be the US and Asia, depending upon prevailing market conditions from time to time. (Table A2–7)

2.8 Polypropylene

Polypropylene demand is expected to grow steadily in the future as a low-cost performance resin, mainly used for industrial components, packaging materials, and general merchandise. The highest growth rate is expected among polyorefin resins. The world polypropylene production capacity will increase from 19.21 million tons in 1992 to 20.43 million tons in 1997, a 4.7% increase.

The significant increase in production capacity will create surpluses in North America and the Middle East. Asia will increase its self-sufficiency rate but will remain as a net importer. Thus, the flow from the former to the latter will continue during the period. (Table A2–8)

2.9 Acrylonitrile

Acrylonitrile demand has once gained popularity as a material for acrylic fiber, but it lags behind rapid growth of polyester fiber. Recently, however, the demand has been invigorated by explosive growth of ABS resin due to the surge in electric, electronic, and automotive applications in industrialized countries. World demand will grow at a slightly less than 3% up until 1997. While the production capacity is yet to expand at an annual pace of nearly 4%, tight supply will continue for the time being. (Table A2–9)

2.10 Ammonia, Urea, and Methanol

According to the World Bank, nitrogen fertilizer supply in the Indian Subcontinent (including India, Pakistan, Afghanistan, Myanmar, and Bangladesh) will be around 2 million tons short of the demand of 12.5 million tons in 1997. Of total, India accounts for more than two-thirds in both production and demand. India is still importing nitrogen fertilizer mainly through the international tender. Major import sources are CIS and the GCCs. For India, it is important to secure some portions of its imports from a stable supply source. If Oman can provide part of its natural gas at an internationally competitive price, the country will be in a good position to develop the nitrogen fertilizer project in cooperation with India. One should not forget a potential competitor, however, the former Soviet Union has been the world largest ammonia exporter, and its surplus capacity may cater to the huge demand in India. India can compare two potential partners, and Oman should be ready to offer a sales point or two.

Finally, methanol is generally in short supply. Demand is expected to grow at 7.7% until 1997. Major growth will come from MTBE. While some predict that the market will nearly achieve a supply and demand balance around 1997, a majority expects that tight supply will be the norm up until 2000, even if the demand from MTBE will slow down. (Table A2-10)

Table A2-1 Estimated Market Size of Petrochemical Products in the World

(Unit: million tons)

	1990	1991	1992	1997	2002
Aromatics	41.7	42.4	43.7	53.2	58.7
Oleffines	102.2	104.6	110.2	142.6	160.5
Resins	72.8	73.3	75.9	93.1	111.3
Elastomers	8.8	8.7	8.7	10.3	11.7
Synthetic fibers	14.4	15.2	15.6	18.6	21.4
Formaldehyde resins	8.0	7.9	8.0	9.4	10.8
Major intermediates	54.1	54.9	58.7	82.7	92.4
Total	302.0	307.0	320.8	409.9	466.8

Table A2-2 Ethylene

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	57.2	60.7	63.9	69.1	73.3	6.4	77.1	6.2	91.9	4.6	95.8	0.8
Capacity utilization rate	95.3	89.7	88.8	83.8	83.7		84.5		84.0		91.1	
Production (a)	54.5	54.5	56.7	58.0	61.4	3.0	65.1	3.6	77.2	4.7	87.3	2.5
Consumption (b)	54.0	54.3	57.1	58.1	60.9	3.1	64.4	3.6	75.6	4.4	86.0	2.6
Balance (a–b)	0.5	0.2	–0.4	–0.1	0.5		0.7		1.6		1.3	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	855.0	630.0	58.3	206.0	482.3
Asia	14,321.0	11,960.0	403.1	219.0	12,185.1
E. Europe	7,667.0	4,246.2	161.0	126.0	4,376.3
Mideast	2,920.0	2,783.0	36.8	181.0	2,628.8
N. America	24,792.0	22,543.0	5.1	119.5	22,560.5
Oceania	470.0	372.4		25.0	347.4
C & S. America	3,046.0	2,444.4	56.1	241.0	2,359.5
EC	17,366.0	14,586.0	1,160.0	1,481.0	14,308.0
Non-EC	1,885.0	1,785.0	173.0	87.0	1,871.0
World total	73,322.0	61,350.0	2,053.4	2,685.5	61,118.9

Table A2-3 Polyethylene

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	30.9	32.5	35.8	38.7	41.3	7.5	43.9	7.3	50.3	4.0	55.3	1.9
Capacity utilization rate	91.3	87.5	85.0	81.5	81.0		82.1		85.7		90.7	
Production (a)	28.2	28.4	30.4	31.5	33.5	4.4	36.0	5.0	43.1	5.2	50.2	3.1
Consumption (b)	27.2	27.8	29.3	29.8	31.1	3.4	32.6	3.7	38.6	4.4	46.9	4.0
Balance (a-b)	1.0	0.6	1.1	1.7	2.4		3.4		4.5		3.3	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	388.0	365.0	126.0	70.0	421.0
Asia	8,609.0	6,545.0	2,270.0	1,561.0	7,152.0
E. Europe	3,473.0	2,075.0	148.0	620.0	1,598.0
Mideast	1,541.0	1,687.0	452.4	1,246.5	592.9
N. America	13,711.0	12,285.0	965.0	2,799.0	10,539.0
Oceania	365.0	226.5	134.0	14.2	346.3
C & S. America	2,010.0	1,535.0	234.1	323.0	1,446.1
EC	9,728.0	7,650.0	4,834.5	4,653.9	7,798.6
Non-EC	1,483.0	1,385.0	813.0	984.0	1,214.0
World total	41,308.0	33,753.5	9,977.0	12,271.6	31,107.9

Table A2-4 Styrene Monomer

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	13.2	13.9	15.3	16.9	17.2	6.8	18.7	7.2	21.9	5.0	22.4	0.5
Capacity utilization rate	96.2	91.0	87.8	82.8	84.4		81.4		79.9		88.5	
Production (a)	12.7	12.7	13.4	14.0	14.5	3.4	15.2	3.7	17.5	3.8	19.8	2.5
Consumption (b)	12.4	13.0	13.6	13.9	14.4	3.8	15.2	4.2	17.3	3.7	19.2	2.1
Balance (a-b)	0.3	-0.3	-0.2	0.1	0.1		0.0		0.2		0.6	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	0.0	0.0	26.0	0.0	26.0
Asia	4,539.0	3,981.4	1,398.0	508.0	4,870.4
E. Europe	1,542.0	835.5	91.0	29.0	872.0
Mideast	400.0	360.0	18.0	268.0	110.0
N. America	6,201.0	4,910.0	207.0	1,003.0	4,057.5
Oceania	120.0	116.9	1.0	31.3	86.6
C & S. America	403.0	325.0	176.7	34.6	467.1
EC	4,000.0	4,000.0	956.3	1,323.0	3,695.2
Non-EC	18.0	15.0	228.2	0.0	243.2
World total	17,223.0	14,543.8	3,102.2	3,196.9	14,428.0

Table A2-5 Polyvinyl Chloride

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	19.6	20.5	21.8	22.5	23.5	4.6	24.0	4.1	25.0	1.3	25.4	0.3
Capacity utilization rate	86.8	85.6	82.6	78.7	78.2		79.8		86.1		92.7	
Production (a)	17.0	17.5	18.0	17.7	18.4	2.0	19.1	2.4	21.6	3.3	23.6	1.8
Consumption (b)	16.6	17.0	17.4	17.0	17.2	0.9	17.9	1.5	20.2	3.3	23.0	2.6
Balance (a-b)	0.4	0.5	0.6	0.7	1.2		1.2		1.4		0.6	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	371.0	320.0	36.0	53.0	303.0
Asia	6,439.0	5,207.0	679.0	487.0	5,347.0
E. Europe	2,440.0	1,312.0	73.0	381.0	1,004.0
Midcast	510.0	453.0	164.8	278.0	339.8
N. America	6,353.0	4,951.0	240.0	1,158.0	3,993.0
Oceania	177.0	145.0	45.0	0.6	189.4
C & S. America	938.0	737.0	143.5	215.0	665.5
EC	5,755.0	4,772.0	2,031.0	1,917.0	4,840.0
Non-EC	562.0	510.5	278.5	222.0	567.0
World total	23,545.0	18,407.5	3,690.8	4,711.6	17,248.7

Table A2-6 Ethylene Glycol

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	7.5	7.9	8.3	8.7	9.1	5.0	10.2	6.3	12.1	5.9	12.3	0.3
Capacity utilization rate	77.0	76.7	74.1	72.2	75.0		72.5		77.3		85.3	
Production (a)	5.7	6.1	6.1	6.3	6.8	4.5	7.4	5.4	9.4	6.7	10.5	2.2
Consumption (b)	5.7	5.8	6.0	6.1	6.4	2.9	6.9	3.9	8.2	5.1	9.2	2.3
Balance (a–b)	0.0	0.3	0.1	0.2	0.4		0.5		1.2		1.3	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	52.0	0.0	60.4	0.0	60.4
Asia	2,035.0	1,857.0	1,211.0	336.0	2,760.0
E. Europe	556.0	323.0	20.0	61.0	282.0
Mideast	740.0	700.0	17.2	700.0	17.2
N. America	3,888.0	3,043.0	204.0	1,059.5	2,204.0
Oceania	15.0	10.0	0.7	0.0	10.7
C & S. America	233.0	126.0	39.1	43.0	122.1
EC	1,191.0	671.0	527.9	303.0	895.9
Non–EC	102.0	79.5	71.5	32.9	118.1
World total	8,812.0	6,809.5	2,151.8	2,535.4	6,470.4

Table A2-7 Propylene

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	57.2	60.7	63.9	69.1	73.3	6.4	77.1	6.2	91.9	4.6	95.8	0.8
Capacity utilization rate	95.3	89.7	88.8	83.8	83.7		84.5		84.0		91.1	
Production (a)	54.5	54.5	56.7	58.0	61.4	3.0	65.1	3.6	77.2	4.7	87.3	2.5
Consumption (b)	54.0	54.3	57.1	58.1	60.9	3.1	64.4	3.6	75.6	4.4	86.0	2.6
Balance (a-b)	0.5	0.2	-0.4	-0.1	0.5		0.7		1.6		1.3	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	455.0	255.0	0.0	80.0	175.0
Asia	9,530.0	7,933.3	460.0	286.0	8,169.3
E. Europe	3,162.0	1,965.9	76.0	108.0	1,891.9
Mideast	61.0	50.0	32.5	5.0	77.5
N. America	13,786.0	11,151.0	252.0	803.0	10,588.5
Oceania	349.0	237.1	0.0	0.0	237.1
C & S. America	1,837.0	1,115.0	14.0	60.0	1,069.0
EC	11,170.0	9,179.8	1,160.0	917.2	9,243.6
Non-EC	1,037.0	804.0	43.0	81.0	766.0
World total	41,387.0	32,691.1	2,037.5	2,340.2	32,217.9

Table A2-8 Polypropylene

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	11.6	13.0	15.3	17.0	19.2	13.4	20.4	12.0	24.2	4.7	24.9	0.6
Capacity utilization rate	92.1	87.5	83.3	80.5	78.1		79.5		80.3		87.2	
Production (a)	10.6	11.4	12.8	13.7	15.0	9.1	16.2	8.9	19.4	5.3	21.7	2.3
Consumption (b)	10.8	11.3	12.7	13.1	13.6	5.9	14.2	5.6	17.2	4.8	21.2	4.3
Balance (a-b)	-0.2	0.1	0.1	0.6	1.4		2.0		2.2		0.5	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	209.0	150.0	25.0	78.0	97.0
Asia	5,678.5	4,603.0	1,302.0	1,213.0	4,692.0
E. Europe	1,140.0	581.0	51.0	229.0	408.0
Mideast	0.0	0.0	154.2	0.0	154.2
N. America	5,586.0	4,239.0	164.0	940.0	3,492.5
Oceania	260.0	190.0	20.0	60.0	150.0
C & S. America	920.0	564.0	87.0	110.0	541.0
EC	4,907.0	4,183.8	2,136.4	2,653.0	3,662.4
Non-EC	511.0	495.0	293.0	413.0	375.0
World total	19,211.5	15,005.8	4,232.6	5,696.0	13,572.1

Table A2-9 Acrylonitrile

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	4.1	4.3	4.3	4.4	4.5	2.4	4.7	2.8	5.1	2.5	5.6	1.9
Capacity utilization rate	95.4	87.3	87.1	84.0	81.0		83.2		87.9		92.5	
Production (a)	3.9	3.8	3.8	3.7	3.7	-1.3	3.9	0.0	4.5	4.0	5.2	2.9
Consumption (b)	3.9	3.8	3.7	3.8	3.9	0.0	4.1	1.0	4.4	2.4	4.8	1.8
Balance (a-b)	0.0	0.0	0.1	-0.1	-0.2		-0.2		0.1		0.4	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	0.0	0.0	0.4	0.0	0.4
Asia	1,228.0	1,004.5	558.0	42.0	1,520.5
E. Europe	523.2	235.0	46.8	42.0	239.8
Mideast	0.0	0.0	16.0	0.0	16.0
N. America	1,575.0	1,368.0	12.3	614.8	735.5
Oceania	0.0	0.0	4.0	0.0	0.0
C & S. America	78.0	59.0	40.7	20.0	79.7
EC	1,120.0	995.0	485.0	329.0	1,146.4
Non-EC	77.0	65.0	79.5	5.0	139.5
World total	4,601.2	3,726.5	1,242.7	1,052.8	3,877.8

Table A2-10 Methanol

Actual/Projected Supply and Demand

(Unit: million tons)

	Actual						Estimated		Projected			
	1988	1989	1990	1991	1992	1988/92(*)	1993	1988/93(*)	1997	1992/97(*)	2002	1997/2002(*)
Capacity	19.6	21.7	22.1	22.3	23.6	4.8	25.8	5.7	37.2	9.5	37.2	0.0
Capacity utilization rate	98.9	90.4	90.6	86.3	85.3		85.4		83.4		90.3	
Production (a)	19.4	19.7	20.0	19.2	20.1	0.9	20.0	0.6	31.0	9.1	33.6	1.6
Consumption (b)	18.6	19.4	19.9	19.9	20.9	3.0	22.1	3.5	30.3	7.7	33.1	1.8
Balance (a-b)	0.8	0.3	0.1	-0.7	-0.8		-2.1		0.7		0.5	

Note: (*) Annual growth rate (%)

World production capacity, production, import/export and consumption in 1992

(Unit: '000 ton)

	Capacity	Production	Import	Export	Consumption
Africa	787.0	635.0	44.4	598.7	80.7
Asia	2,437.7	1,713.0	2,848.0	564.9	3,996.1
E. Europe	3,977.0	3,038.0	223.0	875.0	2,390.0
Mideast	2,629.0	2,356.0	6.3	2,077.9	284.4
N. America	7,291.0	6,167.0	1,460.0	1,855.0	6,772.2
Oceania	2,035.0	2,028.0	47.3	900.0	1,175.7
C & S. America	1,610.0	1,554.0	527.7	1,251.5	830.2
EC	2,802.0	2,550.8	2,718.1	442.0	4,831.3
Non-EC	12.0	39.0	513.0	4.0	548.0
World total	23,580.7	20,080.8	8,387.8	8,569.0	20,908.6

ANNEX 3

DETAIL OF GRADE ANALYSIS OF MINERAL RESOURCES

3 Detail of Grade Analysis of Mineral Resources

3.1 Metal Mineral Resources

3.1.1 Copper and gold

Copper and gold contained in areas having deposits of ophiolite have already grown as important mineral resources for the country. The deposits are the syngenetic deposits created concurrently with basic volcanic rock in the late Cretaceous period, and classified as "Cyprus type massive sulfide deposits." The deposits have been largely developed from gossan outcrops. After continuous geophysical exploration and boring surveys, possible reserves have been determined for the deposits which are developed since then.

The massive sulfide deposits contained in ophiolite, consisting of sulfide minerals such as copper, gold, lead, and zinc, have already been identified as having physical anomaly through airborne geophysical exploration activities. Detailed exploration is planned in the future.

During the field survey, sample analysis was conducted for those obtained from Aarja deposit in Sohar which is mainly mined by OMCO, among other deposits and samples obtained from gossan outcrops of the Hayl–as–Safil and Rakar deposits located northeast of Ibri, wherein development is under consideration.

The result of the grade analysis shows that, of all the accessory components contained in the copper ore, gold can be derived for commercial purpose. Besides this, no other component shows use ability.

(1) Aarja deposit

The Aarja deposit consists of the dog's bone deposit and the main deposit. The latter is intersected by two major faults into three ore bodies. Together with the dog's bone ore body, the Aarja deposit is made up of four ore bodies. The main deposit is 10 – 30m thick and 80m wide, extending 300m from NNW to SSE and having a 30–degree dip in the SSE direction. On the other hand, the dog's bone deposit runs slightly above and parallel to the main deposit, one–thirds in size. It is mined at 100m, 92m, 82m, 67m, and 55m levels. The wall rock around the deposit is volcanic breccia, and the foot wall contains reticulated ore subjected to silification. The wall rock in the deeper sections is basalt. Metaliferous sediments are present in the upper part of the deposit. The cause for formation of the deposit seems to be more or less the same for kuroko deposits. The ore bodies are mainly made of massive sulfide, primarily of pyrite, which sometimes is accompanied with lead, zinc, barite, calcite, and hematite. The major faults intersecting the deposit contain oval-shaped rounded gravels (15cm x 25cm) which originated from basaltic pillow lave in some places. Also, water (pH-5) flows. The mining depth is 400m from the ground, and the deposit continues deeper.

Samples obtained from the OMCO's Aarja deposit have been analyzed, and the result shows the highest grade of copper at 6.45%. Also, 16% – 46% sulfur is contained. This confirms the fact that metal minerals forming the deposit are mainly pyrite, with cubanite in part. Also, gold grade tends to increase with an increase in copper grade. Finally, the sample contains traces of silver, lead, and zinc, with few amounts of bismuth, tin, and arsenic. (Table A3-1)

(2) Hayl-as Safil and Rakar deposits

For these deposits, all the samples were taken from gossan outcrops. All of them contain traces of silver, lead, and zinc, while few amounts of bismuth, tin, and arsenic, are seen in the Aarja deposit. On the other hand, gold is contained regardless of silver grade, probably because 1) samples are taken from the gossan outcrops, and 2) gold is contained in quartz, regardless of the presence of silver.

Samples collected from copper slags in the Rakar deposit contain 1.33% copper and a trace of zinc, indicating that copper smelting has been carried out in Rakar.

3.1.2 Chrome

(1) General

The analysis of chrome ore was conducted for occurrences in OMCO's Ghashabi-2 and RG-2 located in the northern part of the Oman mountain range, and 3E-97, 3E-00, and 3E-61 near Izuki, in the southern part.

The result of analysis shows that chrome ore in the northern part shows more or less the same chemical composition data as those found near Izuki. (Table A3-2) First of all, Cr_2O_3 ranges between 36.86% and 40.66% for all the samples. The maximum level is limited to around 40%, and a higher grade is not obtained. SiO_2 is in the range between 1.95% and 5.11%, and even high grade ore contains 2% - 3%. Al_2O_3 is relatively high, ranging between 17.99% and 22.93%. Cr_2O_3 + Al_2O_3 ranges between 58.53% and 63.60%, and Cr/Fe between 2.39% and 2.73%. Little phosphorus is contained.

The absence of phosphorus is favorable for metallurgical use, but the low content of

Cr_2O_3 makes it unsuitable for chemical and metallurgical purposes. According to the classification by the US Department of Defense (DOD), chemical grade is 44% or over and metallurgical grade 48% or more. On the other hand, for the refractory purpose, the presence of Al_2O_3 is a favorable factor, and the Cr_2O_3 content is sufficiently high. (DOD's standard requires 31% or more Cr_2O_3)

Mineral composition of these ore is a solid solution containing 30% – 35% chromite and 65% – 70% picotite. It is very similar to that of ore used in Japan as a refractory material. Also, the chemical composition is similar to chrome ore used for refractory production in Turkey. (Tables A3–3 – A3–5)

(2) Chromite occurrence 3E–97 (N23.08, 20, 5, and E57.50, 48, 7)

The occurrence is found between Izuki and Muscat, after driving approximately 30km on the highway from Izuki to Muscat, then 200m off the highway to the south. The deposit is located 50m from a circular fort at the end of the wadi. A lenticular outcrop, 10m – 12m wide and 20m long, is found on the side of a 60m–high mountain which is located in the southern side of a river bank, 30m up from the bank. The wall rock is hartzburgite. The deposit is of podiform type, where the lenticular outcrop narrows down over a short distance and disappears. A sharp change occurs between the wall rock and the ore. The chrome ore is of squared, coarse grain crystal structure. It has melanocratic color and has a small amount of gangue minerals. According to BRGM, the ore reserve is estimated at 8,000 tons. The result of the present analysis is compared with that of BRGM's grade analysis in Table A3–6.

(3) Chromite occurrence 3E–00 (N23.12, 27, 8, and E57.53, 31, 3)

The occurrence is located on the south side of the highway between Izuki and Muscat, 9km from the 3E–97 occurrence toward Muscat. On a small hill with relative height of 5m, boulders ranging from fist to human head size are scattered in a 20m x 10m x 5m area. The ore reserve is estimated at a few hundred tons. Chrome ore is exposed 2m wide in the road construction site, and the deposit narrows in the lower part. The wall rock is hartzburgite. The result of the grade analysis is shown in Table A3–6 (already mentioned).

(4) Chromite occurrence 3E–61 (N23.12, 36, 1, and E57.54, 00, 1)

It is located 500m south of the highway, approximately 10km from the 3E–97 occurrence toward Muscat. The deposit runs 40m N40W on a mountain (380m high above the sea level and 70m in relative height from the summit). The vein is 5m – 10m wide and extends mostly vertically. The deposit is of podiform type and the ore is of black coarse grain crystal structure. Fist-size boulders are scattered in the stream and in the flat area. The wall rock is hartzburgite, and dunite is found near the deposit. The ore reserve is expected to increase as exploration progresses. The deposit is accessible by transportation. BRGM estimates the ore reserve to be 4,000 tons. The result of the present analysis is compared with BRGM's grade analysis in Table A3-6.

3.1.3 Manganese

The analysis was conducted for manganese ore found in Jabel Hammer, south of Sur. The Jabel Hammer manganese occurrence (N22.28, 28, 0, E58.37, 20, 0) can be reached by driving 23km on the highway eastward from Ibra, and 15km southward along the Wahaybah sand extending in a southeast direction. The deposit is contained in the *hawasina formation mainly consisting of red-brown chert. It seems to be a sedimentary* manganese deposit subjected to secondary enrichment. The stratum are significantly folded, made up of layers showing a wave pattern or a sharp dip. The vein is 1m - 3m thick, and the ore is black oxidized manganese with metallic gloss in part. The primary mineral is pyrolusite. There are high grade sections and low grade sections which are essentially the chert that has turned into black and looks like manganese ore. About 500m from the deposit, the outcrop of 0.5m - 1.2m wide runs N80W through the chert with a dip of 65 degree south. However, its grade is below 20%, not usable as ore. In addition, there are many outcrops of narrow veins around the site.

The result of the analysis is shown in Table A3-7. [24-1] and [24-2] are samples taken from the fold at the center of the deposit. They contain 32.43% - 40.39% Mn, which is classified as medium-to-low grade. (high grade is 40% - 45%) Also, they have a relatively high phosphorous content (0.15%). Another foreign matter, SiO_2 shows very high content, 32% - 43%. [24-3] is a sample taken from the vein type deposit having a 65-degree dip, located approximately 500m from the main deposit. It has a low manganese content and cannot be an ore.

3.2 Non-Metal Mineral Resources

3.2.1 Quartzite

As for quartzite, the analysis has been made for (1) mineral resources currently used as a silica source, (2) raw materials for crushed-stone aggregate, (3) dolerite as a raw material for rock wool, and (4) silica sand.

(1) Silica resources

1) OMC silica (shale)

OMCO is smelting copper at a plant located 20km west of Sohar, where shale is used as a silica source and limestone as a lime source to be used for blast furnace reaction as well as copper smelting. For this purpose, the company has a crushing plant for silica and limestone, 5km southeast of the mining office.

Samples of silica and limestone obtained at the plant were analyzed, and the result is shown in Table A3-8.

The silica sample contains more than 85% SiO_2, with relatively small contents of foreign matters. Limestone is also high grade (54.8% CaO) with a low impurity content.

2) Silica used by Oman Cement Co.

Oman Cement mines shale as a silica source near its cement plant. The sample was analyzed as shown in Table A3-8. It contains more than 80% SiO_2, with low contents of phosphorous and sulfur, thus is considered to be of high quality.

3) Silica used by Raysut Cement Co.

Raysut Cement Co. is mining quartzite as a silica source from the very old (pre-Cambrian or Cambrian) formation located a few km northwest of its cement plant. The result of the sample analysis is shown in Table A3-8.

The sample contains 61% SiO_2, which is much lower than Oman Cement's silica source. The use of the low grade source reflects the fact that the Salalah region where the company is located is rich with limestone resources, but is limited in silica resources.

(2) Crushed-stone aggregates

1) Yanqul aggregate (Qurn Al-Kabish crushing plant)

Raw materials are all gravels collected from a nearby wadi, which are fine crystallized andesite, green volcanic rock, diabase, and hartzbergite. They are mainly dark green in color and are mixed with white-based quartz schist and silicified shale. Raw rock is abundant and does not require the estimation of ore reserve. The wadi is 1.5 - 2km wide and the plant is located on the mountain side. The result of the sample analysis is shown in Table A3-9.

2) Nizwa crusher aggregate

The source is located in the wadi, on the southeast side of the highway, 10km from Nizwa toward Muscat. Gravels smaller than 750mm are used for crushing.

The result of the sample analysis, as shown in Table A3-9, indicates that the raw rock is mainly calcareous rock having a high CaO content. Around Nizwa, limestone and marble are widely found and used as aggregate materials.

(3) Dolerite as a raw material for rock wool

1) Rusayl dolerite (N23.31, 17, 1, E58.11, 27, 0)

The deposit is located in Rusayl. It is distributed in an oval pattern having a longer diameter of 6km and a shorter diameter of 2.5km, which intersects the road from Rusayl to Ibri. It is basically the hilly mountain range having relative height of 10m – 20m, which is not covered by top soil. The weathering action seems to occur at a depth of 5 – 10m below the ground. The deposit is suitably located for mining and transportation. Geographically, it is located along an industrial area and is intersected by a natural gas pipeline.

The rock wool material is dolerite intruding in sheeted dykes, having green color. In the rock, narrow veins of epidote are subjected to hydrothermal alteration.

The result of the present analysis and that of BRGM's grade analysis are compared in Table A3–10. BRGM's report states that the deposit is suitable for rock wool production.

(4) Silica sand

There are relatively good quality silica sand resources available, which need to be washed to obtain high grade silica. In other countries, silica sand is produced by washing or water mining. However, Oman's silica sand resources are mainly found in the inland areas, where water is difficult to obtain. Furthermore, silica sand is found throughout the world, not suitable for exports.

1) Salil quartzite (N23.20, 55, 1, E58.38, 06, 7)

The resource is located along the Muscat – Quryat highway, approximately 50km from Muscat. It is contained in the Ameden formation AM2 white quartzite sandstone formed in the Ordovician period. The rock is muscovite quartzite having a very high silica content. It has well–developed schistosity and cracks flat. It contains white mica as well as other colored minerals such as tourmaline. The quartzite is located in a 2km x 4km area with relative height of 30m – 60m. There is no top soil coverage. BRGM estimates ore reserve to be approximately 2 million tons. The result of the sample analysis (crushed and washed stone) and that of the raw rock analysis are shown in Table A3–11. The rock seems to produce relatively high grade silica sand by washing it thoroughly after mining and crushing. Thus, the availability of water should carefully be considered.

2) Abu Tan silica sand (N22.00, 58, 0, E57.19, 06, 3)

This is the most promising silica sand resource in the country and is under investigation by the Ministry Petroleum and Minerals.

The deposit is located in the desert in the southeast region, 120km east of Hayma. (the best route is via Yalluni) A flat section of the desert forms a steep slope with relative height of 50m. The landscape extends over 40km in distance. By walking down a service path provided for the boring survey, a loose silica sand layer is seen below a limestone layer. The limestone layer belongs to the Samhan formation in the late Cretaceous period and is sedimented roughly horizontally. The silica sand layer consists of fine grains, shown white or yellowish, pale blue green color. From the result of the boring survey, the layer is approximately 10m thick, and the upper 5m has good quality. The productive deposit is 2km long and 300m wide, with an estimated ore reserve of 5 million tons. Overburden is expected to be more or less the same volume as silica sand to be mined.

The result of the analysis of raw rock is shown in Table A3-11. Since the site is located near Muscat and the rock can be crushed relatively easily, the deposit is considered to be most prospective silica sand resource. However, SiO_2 content remains at a 92% - 94% level, lower than the high grade silica sand (99%), requiring the washing process after mining and crushing. Also, a haul road needs to be constructed for mining. MPM is currently testing the suitability of silica sand for glass production and other purposes.

(5) Other quartzites

1) Al-Khawd silt (N23,37, 06, 2, E58.10, 13, 5)

It is located approximately 10km east of Seeb Airport, near Al Khawd Dam. The silt layer is seen on a 5m-high slope of the dam eroded by a wadi. It is a horizontal sediment formed in the Quaternary and is exposed below a 1 - 1.5m sand and gravel layer. Silt produced is used for farming and industrial purposes. The result of the rock analysis is shown in Table A3-11.

2) Hawshi hematite (chert) (N21.02, 34,1, E57.41, 07, 9)

Samples were taken from the chert layer covering the upper part of Hawshi kaolin, particularly a part with high iron grade. The result of the sample analysis is shown in Table A3-11.

3.2.2 Limestone

Limestone in Oman is one of the most important non-metal mineral resources. It is distributed throughout the country, including east and west sides of the Oman mountain range, and the Salalah region in the south. Various products are under way for production of cement, slaked lime, or crushed stone (aggregate).

Large-scale quarries are operated by Raysut and Rusayl cement mills. In addition, small quarries are mined throughout the country.

The result of the sample analysis is summarized in Table A3-12. In addition to high grade lime, marble seemingly of export quality is seen. Since feasibility of limestone exports is governed by transportation cost, market opportunity arises if the shipping facility is upgraded to allow large-lot transportation. As for marble, export promotion activity will be required.

(1) Nakhl and Awabi

Limestone is found in the plain along the Al Batinah coast in the Oman mountains. Both deposits have high grade (54% CaO). Note that samples from the Nakhl deposit were collected from the area where a hot spring occurs, and those from the Awabi deposit were obtained along the road to Qayut. The Awabi limestone layer has strikes in the N45W direction and a dip of 30 degrees N, and is generally thick.

(2) OMCO

The deposit is located approximately 20km west of Sohar and is mined by OMCO for blast furnace and ore dressing. 2,000 tons are produced monthly. Limestone has high grade (54% CaO) with low contents of impurities.

(3) Yanqul

Samples were obtain in Yanqul. Limestone has already turned to marble due to thermal alteration and other actions. It has high CaO content (55.65) and is light brown in color. Limestone and marble of similar types are widely found around the town.

(4) Marble deposits produced by Oman Marble Co.

1) Khumulo

The Khumulo deposit is located around 35km southwest of Nizwa, where 500 tons of marble are produced monthly. Commercial exploitation was started two years from white or light brown marble boulders. Now, the outcrops are mined. Production yield is 50% - 60%, and CaO grade is high at a 55% level.

2) Wadi Al-Moaydeen (N22.57, 58,5, E57.40, 04, 9)

The deposit is located in Wadi Al-Moaydeen, 20km northeast of Nizwa, 4km on the upstream side. Huge, black marble rocks with relative height of 150m are exposed on the both sides of the 100m wide wadi. Commercial quarrying is scheduled to start in 1994. Product quality is high with 54.8% CaO. Color is not closely associated with chemical composition, but black marble tends to have a relatively low CaO content.

(5) Jabel Hammer

Limestone in orcher color is found 5 - 10km northwest of the Jabel Hammer manganese deposit, covering a 2km x 2km area with relative height of 20 - 30m. It is completely exposed with no top soil coverage, containing 50.9% CaO and 6.20% SiO_2.

(6) Oman Cement Co.

Samples were collected from the face bench under mining by Oman Cement Co. The result of the analysis shows 51.6% - 53.9% CaO, 1.4% - 2.7% Mao, and 0.6% - 1.4% SiO_2.

(7) Raysut Cement Co.

Samples were collected from the face bench under mining by Raysut Cement Co. The result of the analysis shows 50.5% CaO, 0.46% MgO, and 6.60% SiO_2, with lower silica content than limestone obtained from Oman Cement Co.

(8) Quryat limestone

A huge limestone body is located approximately 16km from Quryat toward Muscat. CaO content varies greatly between 42% and 55%. Ore reserve is large.

(9) Aynahn limestone (N23.17, 03, 0, E58.52, 39, 8) - plant site

It is located a few km from Quryat and is widely found from the north of the town to the northwestern part. It is conveniently located near the road for mining and transportation.

The limestone layer belongs to the Eocene epoch of the Tertiary period. Ore grade is relatively high at 55.4% - 55.7% CaO. Rock is slightly brittle and has a nodular pattern in part. In the geological map, the site is described as brittle limestone and noduler limestone. It has white color but shows yellowish white. The mountain with relative height of 50m - 150m is covered with white color and is visible from remote locations. There is no top soil coverage. The deposits extends 2 - 3km north and south, and 8km east and west.

(10) Abu Tan upper limestone (N20.00, 58, 0, E5,19, 06, 3)

Limestone cover the upper section of the Abu Tan silica sand and has high impurity content including many fossil shells. The result of the sample analysis shows high silica and alumina contents; 47.0% CaO, 13.5% SiO_2, and 0.36% Al_2O_3.

(11) Wadi Hiza limestone (N17.01, 43, 9, E53.54, 46, 0)

The deposit is located in a mountain at an altitude of 400m – 500m, behind Salalah and part of the northern mountain range, which can be reached via Raysut Cement Co.

Rock is essentially re-crystallized limestone and would have been used as marble if there was no fissure or crack. Unfortunately, small cracks in reddish brown color would result in a poor production yield. The area is covered with greens. Although limestone is widely distributed throughout the mountain, no quarrying permit has been issued. The samples show high grade with 55.7% CaO.

(12) Rakoob limestone (N17.01, 56, 4, E53.52, 23, 1)

It is located approximately 15km northwest of Wadi Hiza, at an altitude of 500m above the sea level. There are pasture areas nearby for livestock and camels, with many trees covering wide areas. The site can be reached by driving northward from Wadi Hiza, passing a plateau at an altitude of 1,030m, and then going down along the ridge in a southwest direction to the slope facing the south. It forms a karst plateau where the road ends. In 1985, the Ministry of Petroleum and Minerals conducted a boring survey at five locations. The deposit is generally recrystallized high grade limestone (99% $CaCO_3$) having an estimated ore reserve of 13 million tons. The samples collected from the surface also show a very high grade (55.7% – 55.8% CaO) with a low SiO_2 (0.12% – 0.29%) content.

(13) Tagah stone (Arzat miliolite)

This is coarse sandstone containing limestone in the Quaternary period, located on the coast 15m east of Salalah. The deposit forms small hills with relative height of 2 – 5m and is used as construction materials in Salalah. At present Noor Al-Jazeera Trad and Cont E.S.T. are quarrying the stone. The ore reserve is small. Since the mountain range on the north side of Salalah is entirely made of limestone, sand on the beach is mostly limestone. This is a very special type of sandstone containing 48.3% CaO and 9.41% SiO_2.

3.2.3 Dolomite

The result of the analysis of dolomite samples is shown in Table A3–13. While Hatab's dolomite has high grade sufficient for industrial use, dolomite from other sources has a low MgO content and is not suitable as industrial materials.

(1) Shuwaimiyah center

Shuwaimiyah's massive gypsum deposits contain several thin dolomite layers. Samples were obtained from a 0.5m–thick layer in the central part of the gypsum deposit and were analyzed. The result shows 29.7% CaO and 16.5% MgO.

(2) Hatab dolomite

The deposit is located approximately 40km from Salalah along the Thumrait – Salalah road. On a 4 – 6m high slope on the east side of the road, it is sedimented roughly horizontally (with a slope of 3–degree NNE). The dolomite layer constitutes the lowest stratum of the Rus formation, the Eocene epoch of the Tertiary period, below which limestone in the Umm Redhuma formation lies. It is 6m thick with little variation to cover a 2km x 5km area. To mine the deposit, the removal of a surface layer made of recrystallized or weathered limestone is necessary to 2 – 4m in depth. Stratification is very clear. The limestone is brittle and chalky, susceptible to weathering, but has high grade.

(3) Thumrait Raysut pit

The gypsum mining pit in Thumrait developed by Raysut Cement Co. contains a 0.5m thick dolomite layer. The result of the sample analysis shows 24.8% CaO, 18.9% MgO, 10.5% SiO_2, and 1.66% Al_2O_3.

3.2.4 Gypsum

The result of the sample analysis is summarized in Table A3–14. Gabah's gypsum contains 44.4% – 48.7% SO_3, which is high grade suitable for cement production. In particular, for Oman Cement Co. which is using the Thumrite deposit located 900km away, the development of the deposit will reduce a distance for transportation to 300km. Gypsum produced from the Thumrite deposit is high grade in a crystal form, but contains many impurities in a stripe type.

(1) Ghaba gypsum

The gypsum deposits are located 40km east of Ghaba Motel by driving along the graded road eastward. Samples were taken at two locations, the Ghaba road site (N21.15, 49, 0, E57.32, 19, 7) and the Ghaba four stone site (N21.15, 49, 0, E57.32, 19, 7). Geologically, the deposits are part of the Dam formation in the Miocene epoch of the Tertiary period, and the upper part is marl. They are of evaporative sedimentary deposit and are 0.8 – 1.0m in thickness. Top soil coverage is 1m – 1.5m, although it is absent in some part. Unlike the Thumrait and Shuwaimiyah deposits, gypsum comes off by the order of millimeter.

The samples contain 44.40% – 48.70% SO_3 and 18.6% – 13.1% Ig.loss. Because of high grade, some can be used for cement production.

(2) Shuwaimiyah gypsum

Shuwaimiyah is located along the coast, approximately 200km northeast of Salalah. A white cliff made of limestone rises 250m in front of the beach, extends 20 – 30km east and west to form a shore terrace of 1 – 1.5m wide. In the middle of the beach, there is a village consisting of around 40 houses. Starting from 10km west of the village, the gypsum deposit extends approximately 11km westward, and 1 – 1.5km wide. Distance from the center of the deposit to the beach is around 1km. The deposit belongs to the Rus formation in the Eocene epoch of the Tertiary period. It has a strike running roughly east and west, and a dip of 3 – 5 degrees northeast. The Rus formation is divided into 5 sub–formations. Lower two sub–formations are particularly important and contain 0.5 – 2m thick chalky dolomite layers. There is no top soil coverage, except local coverage of sand and gravel layer formed in the Quaternary period. Thus, the deposit is mostly exposed.

The deposit is 90m thick throughout the Rus formation, of which around 40m can be mined. The Ministry of Oil and Minerals conducted a boring survey in April until July 1993 to drill four 35m bores and four 70m bores.

Based on the result, the ore reserve is estimated to consist of a 10,000m strike, 500m wide north and south, 40m thick, multiplied by specific gravity of 2.5 and safety factor of 0.7. Samples were collected from 3 locations in the deposit. The result of analysis shows high grade, 33.20% – 33.70% CaO, 44.40% – 48.70% SO_3, and 19.6% – 20.9% Ig.loss.

(3) Thumrait gypsum

The deposit is only one productive gypsum deposit, mined by Raysut Cement Co. and Oman Cement Co. It is located 55km north of Salalah and faces a paved road passing through a desert. At present, three pits are in operation, from the south, Raysut Cement Company's pit, ATT's pit, and a new pit northwest of the ATT pit. The Raysut pit produces 10,000 tons annually, and the ATT pit 25,000 tons. The Raysut pit is excavated by the 15m–high bench method, using explosives and taking out gypsum without crushing. On the other hand, the ATT pit is excavated by breakers, and gypsum rock is crushed at the site and is transported by 50–ton trucks over a distance of 900km to Oman Cement Co. The result of the analysis of samples obtained from the two pits shows 41.70% – 45.70% SO_3 and 18.2% – 19.9% Ig.loss. While crystallized gypsum is high grade, the stripe ore (centimeter wide) contains relatively large amounts of insoluble materials and iron. The ore reserve is considered to be sufficient for commercial exploitation.

3.2.5 Kaolin

The result of the sample analysis (including X–ray diffraction analysis) is shown in Table A3–15. The Hawshi kaolin deposit is high grade from the center to the eastern section. Kaolin content is particularly high in the central section. It should be noted, however, that the kaolin layer is partially colored by the above layer – chert containing Fe_2O_3 – and is not suitable for paper making. It can be used for ceramic and porcelain production if some coloring does not present a problem (such as products supplied to the domestic market). No kaolin content has been detected in other samples.

(1) Fulayi silt (N22.25,50,6, E29.21,10,6)

The area faces a grade road between Sur and Al Kamil and 7km east of the Al–Tahwa bus stop. The deposit belongs to the Umm or Redhuma formation and forms gentle hills (120 – 130m above the sea level, with relative height of 10 – 20m), flat on the top which is covered 1 – 2m with fist–size gravels. The silt layer is 10 – 15m and often contains small veins of gypsum. Samples are light yellow–brown color. The result of the sample analysis indicates the presence of quartz and calcite, while showing little kaolin content.

(2) Qaboos (Al–Khawd) silt (N23.35,34,1, E5811,35,9)

Jam'at Qaboos silt is found near the University of Qaboos. Because of flat land, no outcrop has occurred. Silt samples were collected in the wadi, and the result of the analysis shows high content of dolomite (14.2% – 19.2% MgO) as well as some silica.

(3) Hawshi kaolin

The deposit is located approximately 95km east of Ghaba, the desert area in the central part of the country. It can be approached by driving the graded road for 55km and a few sign of traffic for the remaining 40km. The last 2km runs over a small sand dune. The kaolin layer belongs to the Minjur formation in the Triassic period, which is sedimented mostly flat. The lower section of the iron-contained chert layer embraces a 2 - 5m thick kaolin layer. The upper section of the kaolin layer consists of a 5 - 10mm diameter pisolitic and bauxite (pale pick or pale brown) layer of 0.2 - 0.5m thick, and the lower section is slightly white kaolin. The deposit extends the range of 1km x 12km. The result of the X-ray diffraction analysis indicates that the central part is highest in grade and contains 80% kaolin. The southwest edge has transformed to silica. The Ministry of Petroleum and Minerals has completed the boring survey covering 24 locations and is determining ore reserves and grades. Note that the kaolin layer is covered by chert containing a large amount of iron, which moves down and color kaolin slightly. Thus, it cannot be used for paper making that requires a high level of whiteness.

3.2.6 Coal (N22.13,51,7; E59.25,11,3; altitude: 187m; pit site)

Coal deposits are found in Wadi Musuwa, approximately 40km south of Sur. The site can be approached by starting 20km southwest of Al Kamil, advancing 25km to northeast, then 10km to northwest. On the Sur side of Wadi Musuwa, there is Wadi Sifsaw. A boring survey was started in 1980 and 55 holes were drilled by diamond bits, totaling 13,000m of length. At present, the survey is in Phase 3[1)]. In addition to the boring survey, 50 tons of coal will be mined in a pit and will be analyzed by sub-industrial tests. Geological formation is the Eocene epoch of the Tertiary period, has strike length of 13km with no fault. At the outcrop, the strike becomes N10W, and a steep dip of 45 degrees W occur. The upper rock is sandstone which is very hard due to silification. The lower rock is sandstone and shale. The coal seam is 2 - 5m thick. From the result of the boring survey, coal reserves are estimated at 40 million tons (until 600m depth). The coal type is subbituminous, 7 - 30% ash content, 28 - 40% volatile matter, 35 - 52% fixed carbon, and 5% sulfur, with calorific value of 1,200 BTU/lb. Because of high sulfur content, it is very difficult to exploit the coal deposits on a commercial basis.

3.2.7 Brine

In Oman, there are three sedimentary basins containing rock salt, from south to north, the Fahud Salt Basin, the Ghaba Salt Basin, and the South Oman Salt Basin. At present, Modern Salt Company is producing industrial salt near Sulaif.

In 1990, the Ministry of Commerce and Industry analyzed brine produced from around

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[1)] The survey was conducted as a United Nation Product for a 2-year period between 1992 and 1993

50 oil wells in Um Al-Sameen. The result is shown in Table A3-16. Excepting lithium (Li), no usable mineral resource has been identified. Also, lithium content is too low to be commercially exploited. Globally, crude ore containing 1.5% Li_2O is utilized and refined to a 5 - 7% grade for shipment.

Table A3-1 Analysis of Copper Ore

Sample No.	Location	Au	Ag	Cu	Pb	Zn	Bi	Sb	As	S	SiO_2	Al_2O_3
		ppb	ppm	%	%	%	%	%	%	%	%	%
3–1	OMC Aarja Dogsbone–DP2–92m–1	451	6	6.450	0.001	0.045	<0.01	<0.01	<0.01	19.18	46.90	6.58
3–2	OMC Aarja Dogsbone–DP2–92m–2	201	4	4.980	0.002	0.040	<0.01	<0.01	<0.01	17.10	49.00	8.68
4–1	OMC Aarja Dogsbone–DP3–92m–1	285	5	4.271	<0.001	0.028	<0.01	<0.01	<0.01	16.53	46.15	11.71
4–2	OMC Aarja Dogsbone–DP3–92m–2	256	5	3.314	0.002	0.001	<0.01	<0.01	<0.01	18.48	44.15	11.22
5–1	OMC Aarja main–DP4–82m–1	27	<2	0.027	0.002	0.005	<0.01	<0.01	<0.01	42.61	9.85	5.66
5–2	OMC Aarja main–DP4–82m–2	134	<2	0.071	0.003	0.029	<0.01	<0.01	<0.01	42.97	10.15	5.56
6–1	OMC Aarja main–DP11–82m–1	143	3	3.265	0.009	0.110	<0.01	<0.01	<0.01	21.72	36.55	12.26
6–2	OMC Aarja main–DP11–82m–2	188	4	4.095	0.001	0.032	<0.01	<0.01	<0.01	15.92	48.70	11.17
7	OMC Aarja main–DP1–82m	4	<2	0.021	<0.001	0.015	<0.01	<0.01	<0.01	0.16	42.55	16.77
12–1	Hayl–as–Safil Gossan 1	350	<2	0.023	<0.001	0.003	<0.01	<0.01	<0.01	0.60	82.85	0.09
12–2	Hayl–as–Safil Gossan 2	62	<2	0.021	<0.001	0.001	<0.01	<0.01	<0.01	0.19	81.50	0.25
13–1	Rakar Gossan 1	239	<2	0.181	<0.001	0.015	<0.01	<0.01	<0.01	0.27	55.70	11.32
13–2	Rakar Gossan 2	294	<2	0.168	<0.001	0.009	<0.01	<0.01	<0.01	0.25	65.60	8.50
13–3	Copper slag (karami)	343	<2	1.332	0.003	0.045	<0.01	<0.01	<0.01	1.58	24.15	3.39

Table A3-2 Analysis of Chromite Ore

(Unit: %)

Sample No.	Location	Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	CaO	MgO	S	P_2O_5
8-1	OMC Chromite Ghashabi-2	40.03	14.26	2.06	22.93	0.39	16.25	0.008	<0.01
8-2	OMC Chromite RG-2	40.65	14.15	1.95	22.95	0.37	15.92	0.085	<0.01
19-1	Chromite 3E97-1	36.86	13.97	5.11	21.67	2.23	15.54	0.047	<0.01
19-2	Chromite 3E97-2	37.19	15.59	4.72	21.60	1.92	14.50	0.038	<0.01
19-3	Chromite 3E97-3	39.41	14.87	2.91	22.69	1.11	14.89	0.038	<0.01
20	Chromite 3E00	40.66	15.69	4.66	17.99	0.54	16.04	0.047	<0.01
21-1	Chromite 3E61-1	39.69	15.82	2.61	21.72	1.20	14.69	0.041	<0.01
21-2	Chromite 3E61-2	39.69	15.76	3.62	22.28	1.38	14.57	0.038	<0.01
21-3	Chromite 3E61-3	40.55	16.05	2.19	22.21	1.02	14.36	0.047	<0.01

Table A3-3 Chemical Composition Example of Some Chrome Ores

(Unit: %)

District	Cr_2O_3	FeO	Al_2O_3	MgO	SiO_2
Theoretical Comp.	67.90	32.10			
Philippines	51.72	11.61	11.38	15.93	3.72
Turkey	48.17	10.64	10.41	18.83	6.47
U.S.A	50.99	14.65	16.21	13.40	0.42
Japan Tottori	37.71	8.87	31.61	19.53	0.94

Source: Kunio Yoshida "Knowledge and Trade of Minerals"

Table A3-4 Type of Chrome Ore

(Unit: %)

Chemical Composition	Cr_2O_3	FeO	Al_2O_3	MgO	SiO_2
Type of Minerals					
Chromite Series	53.4	18.0	12.2	13.6	1.5
Picotite Series	32.5	18.7	26.6	17.5	3.1

Source: Kunio Yoshida "Knowledge and Trade of Minerals"

Table A3-5 Refractory Grade Chromite of Turkey Production

(Unit: %)

Chemical Composition	Cr_2O_3 (over)	SiO_2 (over)	Al_2O_3	MgO	FeO	CaO
23 KE (L)	43	4	12	17	15	0.3
44 BLI (L)	38	5	22	19	16	0.6
44 BFC (C)	41	2	22	19	16	0.6
55 KRS (C)	50	2	15	16	17	0.3

Source: Industrial minerals Jan.1990

(L) : Massive Lumpy Chrome (C) : Concentrates Chrome

Table A3-6 Chromite Ore at 3E-97

3E-97	Cr_2O_3 %	Fe_2O_3 %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	Cr_2O_3+Al_2O_3 %	Cr/Fe
BRGM	38.36	14.54	4.12	24.63	1.01	15.96	62.89	2.58
JICA Analysis	37.82	14.81	4.25	21.99	1.75	14.97	59.81	2.43

3E-00	Cr_2O_3 %	Fe_2O_3 %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	Cr_2O_3+Al_2O_3 %	Cr/Fe
JICA Analysis	40.66	15.69	4.66	17.99	0.54	16.04	58.65	2.47

3E-61	Cr_2O_3 %	Fe_2O_3 %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	Cr_2O_3+Al_2O_3 %	Cr/Fe
BRGM	39.28	15.99	3.78	23.36	0.96	15.76	62.64	2.41
JICA Analysis	39.98	15.88	2.81	22.07	1.20	14.54	62.05	2.40

Table A3-7 Analysis of Manganese Ore

(Unit: %)

Sample No.	Location	Mn	Fe	SiO_2	Al_2O_3	P_2O_5
24-1	Jabel Hammer Manganese-1	32.43	0.20	43.48	0.22	0.15
24-2	Jabel Hammer Manganese-2	40.39	0.16	32.64	0.26	0.16
24-3	Jabel Hammer Manganese-3	16.55	0.42	69.72	3.60	0.14

Table A3-8 Analysis of Silica Resources

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O_5	S
OMC Silica	85.16	3.82	2.22	0.80	0.07	<0.01	0.033

	CaO	MgO	K_2O	Na_2O	SiO_2	Al_2O_3	TiO_2
OMC Limesone	54.2	0.59	0.008	0.004	0.18	0.35	0.004

	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O_5	S
Oman Cement Co.							
Silica bench	81.60	4.81	2.42	1.42	0.48	0.04	0.027
Silica hopper	80.54	5.72	2.75	1.23	0.36	0.05	0.025
Raysut Cement Co.							
Silica	61.24	10.64	4.29	1.80	2.44	0.12	0.058

Table A3-9 Analysis of Crushed-stone

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O_5	S
Yanqul Aggregate	38.76	3.26	7.24	25.20	4.00	<0.01	0.060
Nizwa Crusher Aggregate	3.48	0.81	0.67	14.10	34.66	<0.01	0.058

Table A3-10 Analysis of Dolelite

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	LOI	S
JF116a	54.00	13.70	11.05	7.40	2.75	4.20	0.11	1.80	0.21	0.30	3.50	6.67
JF116b	55.20	14.10	10.35	5.10	3.45	5.35	0.60	1.40	0.27	0.21	3.45	7.41
Analysis												
Dolelite unweathered	17.20	14.99	11.01	10.44					6.43	0.13		0.060
Dolelite weathered	30.12	14.61	12.63	8.74					3.92	0.17		0.038

Source: BRGM Report

Table A3-11 Analysis of Quartzite and Silica Sand

(1) Salil Quartzite

1) After washing

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	LOI
184	99.10	<0.01	0.10	0.10	<0.20	<0.20	0.05	0.05	<0.02	<0.05	<0.01

2) Before washing

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O_5	S
Quartzite white	94.20	1.80	0.44	0.07	0.21	<0.01	0.038
Quartzite pale brown	92.08	1.40	0.38	0.06	0.56	<0.01	0.041

(2) Abu Tan Silica Sand

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	P_2O_5	S
Abu Tan Silica Sand-1	91.22	1.49	0.28	0.09	0.13	<0.01	0.038
Abu Tan Silica Sand-2	89.38	1.82	0.41	0.17	0.55	<0.01	0.055
Abu Tan Silica Sand-3	90.18	1.42	0.29	0.13	0.30	<0.01	0.129
Al-Khawd Silt	30.96	7.24	4.46	9.55	16.89	0.06	0.038
Hawshi Hematite	64.14	0.53	28.03	0.04	0.4	<0.01	0.195

Source: BRGM Report

Table A3-12 Analysis of Limestone

(Unit: %)

Sample No.	Location	CaO	MgO	K_2O	Na_2O	SiO_2	Al_2O_3	TiO_2
1	Nakhl	54.6	0.27	0.039	0.011	1.59	0.11	0.006
2	Awabi	54.8	0.58	0.033	0.009	0.82	0.24	0.009
9	OMC site	54.8	0.59	0.008	0.004	0.18	0.35	0.004
11	Yanqul	55.6	0.32	0.005	0.011	0.28	0.04	0.002
15	Oman Marble Khumulo brown	55.7	0.27	0.005	0.004	0.25	0.03	0.003
16	Oman Marble Khumulo black	55.0	0.50	0.012	0.007	1.02	0.05	0.005
18	Oman Marble Al Moaydeen	54.9	0.95	0.006	0.017	0.33	0.02	0.002
25	Jabel Hammer	50.9	0.39	0.065	0.016	6.20	0.39	0.028
31	Oman cement bench 1	51.6	2.70	0.051	0.051	1.35	0.35	0.024
32	Oman cement bench 2	53.9	1.42	0.029	0.019	0.64	0.17	0.010
37	Quryat mountain white	46.2	0.07	0.029	0.024	16.2	0.31	0.018
38	Quryat whitish gray	42.5	0.14	0.069	0.024	21.9	1.06	0.065
39	Quryat road site 1	54.2	0.16	0.140	0.023	1.66	0.64	0.049
40	Quryat road site 2	55.2	0.11	0.043	0.010	1.11	0.21	0.018
41	Aynahn bench	55.4	0.20	0.022	0.004	0.64	0.07	0.004
42	Aynahn road	55.7	0.21	0.015	0.003	0.18	0.05	0.003
49	Abu Tan upper	47.0	0.64	0.045	0.048	13.50	0.36	0.029
57	Raysut cement	50.5	0.46	0.160	0.076	6.60	0.15	0.019
59	Wadi Hiza	55.7	0.19	0.007	0.006	0.17	0.04	0.003
60	Rakoob 1 upper	55.7	0.14	0.003	0.003	0.29	0.01	0.002
61	Rakoob 2 lower	55.8	0.20	0.002	0.001	0.12	0.01	0.001
69	Tagah stone	48.3	1.02	0.100	0.014	9.41	0.32	0.015

Table A3-13 Analysis of Dolomite

(Unit: %)

Sample No.	Location	CaO	MgO	K_2O	Na_2O	SiO_2	Al_2O_3	TiO_2
55	Shuwaimiyah center	29.7	16.5	0.082	0.320	1.49	0.28 *	0.015
62	Hatab upper	28.4	19.9	0.140	1.040	3.26	0.52	0.026
63	Hatab lower	29.4	20.4	0.094	0.910	1.69	0.29	0.015
67	Thumrait Raysut pit	24.8	18.9	0.270	0.039	10.5	1.66 *	0.065

Note: *Include gypsum

Table A3-14 Analysis of Gypsum

(Unit: %)

Sample No.	Location	CaO	SO_3	Fe_2O_3	P_2O_5	Ig. loss	Moisture	Insolubles
47	Ghaba road site	35.40	48.70	0.07	0.02	13.1	11.6	1.92
48	Ghaba four stone	33.30	44.40	0.20	0.01	18.6	16.6	2.38
53	Shuwaimiyah west	33.70	45.50	0.01	0.01	19.8	19.4	0.51
54	Shuwaimiyah center	33.30	45.70	0.00	0.01	20.2	19.8	0.26
56	Shuwaimiyah east	33.20	44.40	0.01	0.01	20.9	19.4	0.88
64	Thumrait Raysut pit	33.10	44.80	0.01	0.01	20.2	19.4	0.34
65	Thumrait Raysut crystal	33.20	45.70	0.00	0.01	19.8	19.2	0.65
66	Thumrait Raysut layer	33.00	41.70	0.06	0.01	22.9	18.2	0.74
68	Thumrait ATT	32.40	45.00	0.01	0.01	20.5	19.9	0.34

Table A3-15 Analysis of Kaolin

(Unit: %)

Sample No.	Location	SiO_2	Al_2O_3	K_2O	Fe_2O_3	MgO	Na_2O	CaO	Fe_2O_3	True S.	Bulk Density	Ig. loss	Moisture	Brightness by Hunter	X-ray analysis result
23-1	Fulayj east	50.5	15.8	1.61	6.93	1.59	1.07	7.88	0.04	2.80	1.27	13.7	4.47	25.4	
23-2	Fulayj north	49.9	16.0	1.60	6.78	1.49	1.18	7.90	0.05	2.80	1.24	14.2	4.64	25.2	Qz:80%Calcite:20%Kaolin:Trace
28	Qaboos brown	27.4	3.34	0.44	4.38	14.2	0.45	18.4	0.02	2.70	1.13	31.0	3.27	38.1	
29	Qaboos white	9.74	0.85	0.04	0.72	19.2	0.05	26.8	0.01	2.78	1.39	42.5	0.85	66.2	Dolomite:70% Quartz:20%
43	Hawshi center	42.7	36.3	0.09	1.96	0.28	0.81	0.17	0.03	2.62	1.18	14.8	5.10	45.2	Kaolin:80%
45	Hawshi east	42.9	36.9	0.05	1.45	0.33	1.02	0.22	0.02	2.62	1.20	15.2	5.50	51.0	
46	Hawshi west	80.6	9.83	0.21	0.92	0.37	0.52	0.24	0.02	2.65	1.33	5.43	3.30	37.6	Quartz:85% Kaolin:5%

Table A3-16 Analysis of Brine

pH 4.9-6.2,	Ca	2,800- 7,900 ppm,	Mg	315- 4,400 ppm,
	Na	92,000-116,000 ppm,	K	2,500- 6.200 ppm,
	SO_4	380- 1,700 ppm,	Cl	168,000-202,000 ppm,
Alkalinity M		5.3 - 25 ppm,		
	Total	11,000- 32,000 ppm,	Carbonate	5.2 - 25 ppm,
Non-Carbonate		11,000- 32,000 ppm.		
	Li	5.0- 8.7 ppm	Sp.Gravity	1.200 - 1.204

Source: Ministry of Commerce and Industry, 1990