DEVELOPMENT OF MINERAL-BASED INDUSTRIES

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ABSTRACT

Prospects of rich mineral-resources in Pakistan are evident from the occurrence of major mineralized zones and associated mineral depositions. However, the country is importing substantial amount of ores and minerals, and mineral-based products and chemicals from abroad, despite the fact that a number of public and private organizations have been engaged in mineral-development work. The role of mineral sector, in terms of GNP, in Pakistan is also quite insignificant.

Technologies based on setting up of mineral industries are required to harness the available and potential mineral-resources of the country for national economic development. Scientific and technological research in mineral development, for utilizing the potential of mineral resources, are requirement of mineral-based chemicals and products. To meet the challenge of WTO, cheap local technologies need to be developed, based on indigenous, abundantly available raw materials.

INTRODUCTION

Table 1 to 3 show that several billions of rupees of mineral- based chemicals and products are imported in the country, despite the fact that important types of minerals are present in the country. It contains sedimentary minerals, including evaporates, in the salt range; basement rocks; ultramafic mineralization containing chromite, magnesite with potential of Pt, Ni, Co; diorite-granodiorite related rocks of Dir, Chitral and Swat, with potential of copper, lead-zinc, manganese, uranium, lead, gold, silver, etc; andesite and intrusive rocks of Chilghazi containing copper, gold, silver and magnetite; the granites and metagranite with potential of U, Th, Rare earths; the silica deficient syenite containing K, Al, Gallium, etc.

From mining and reserve point of view, these available and potential deposits are classified as:

- Huge to large deposits, such as carbonates, evaporites, oxides gypsum anhydride, halite, silica sand, quartzite, coals, olivine, serpentine.
- deposits requiring mid-term investment, such as chromite, magnesite, copper, gold, gemstones.
- Deposits for long-term investment, such as coal, ferrous and non-ferrous (base metals), platinum, gold, gallium, rare earths, etc.

Feasibilities for utilization of the mineral occurrence in the country were completed at PCSIR for the following:

Minerals for Iron & Steel
Iron Ores, Manganese, Fluorite, Chromite, Manganese

Base Metals
Copper, Lead, Zinc

Minerals for Ceramics Industries
Bauxite and Laterite, Rare Earths

Precious and Economic Minerals
Gold & Silver, Gemstones , Tin, Tungsten, Nickel, Antimony

Industrial Minerals & Advanced Engineering-Materials
Asbestos, Graphite, Fluorite, Baryte, Gypsum, Building and Structural Stones, Quartz Glass Sand, Feldspar, Garnet, Magnesite, Calcite, Limestone and Dolomite, Sulphur, Soapstone, Ochres, Phosphate, Celestite, Coal, Nepheline Syenite, Halite

GEOCHEMICAL, MINERALOGICAL AND PROCESSING PROJECTS

To harness the reserves of mineral resources and grade with respect to process feasibilities, the mineral-reserves estimation is required to be investigated by geochemical and mineralogical modeling, to find their economic potential by undertaking R&D projects involving geochemistry, ore petrography, process-mineralogy, mineral processing and product development, as follows:

i. **Short-term projects:** Development of available reserves, geochemical sampling for feasibility

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Table - 1: Import Data of Chemicals (1996 - 2000)

Chemicals	1996-97		1997-98		1998-99		1999-2000	
	Qty (Tons)	Rs. (mil)	Qty (Tons)	Rs. (mil)	Qty (Tons)	Rs. (mil)	Qty (Tons)	Rs. (mil)
Aluminium hydroxide	4,912	57	4,788	81	4,910	80	3,748	66
Aluminum Oxide	1,596	28	1,479	27	1,242	23	1,937	38
Barium Carbonate	2,708	32	3,014	30	1,448	24	3,422	34
Barium Sulphate	40	1	131	1	284	4	304	3
Calcium Carbide	8,222	142	6,459	123	5,804	111	3,677	69
Calcium Carbonate	2,645	40	1,987	30	2,463	46	2,605	50
Calcium Chloride	333	4	701	10	924	16	283	6
Carbon black	5,340	127	5,479	151	5,867	170	5,216	144
Carbonate-other	507	32	215	13	469	21	217	8
Chemical prepared graphite	43	15	115	3	159	11	83	9
Chromate salt	227	8	367	18				
Chromium oxides	187	15	215	17	221	21	257	24
Coal-tar products	4,975	30	1,387	40	841	42	2,763	66
Cobalt oxides	4	4	12	11	19	23	58	11
Corudum	400	12	260	6	227	9	452	13
Inorganic – other	570	14	105	25	877	33	1,497	35
Inorganic Phosphates	4,520	139	5,472	142	5,534	185	6,359	255
Inorganic Sulphates	10,482	125	8,918	128	12,784	162	13,544	1,192
Iodine	21	5	28	10	19	18	31	13
Iron compounds	2,386	48	2,311	59	3,107	97	4,987	215
Lab. Chemicals	77	25	39	5	73	13	8	10
Lead compounds	182	8	58	3	163	8	138	6
Maganese compounds	105	4	105	4	265	13	300	14
Magnesium Oxide	427	11	256	110	188	10	177	10
Mercury	68	13	60	12	121	25	80	18
Nickle catalyst	192	54	684	264	80	28	156	52
Nitric Acid	1,006	13	1,283	18	1,692	24	1,732	25
Phosphorous	108	9	154	14	158	16	161	14
Pigment – Leather	196	28	249	29	159	27	170	33
Pigment base chrome	456	35	404	39	540	59	900	94
Pigment base TiO_2	6,570	391	8,329	683	7,545	725	8,173	849
Pigment prepared	191	15	227	17	146	15	143	15
Inorg Pigments	2,679	656	3,085	770	2,920	866	3,159	873

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Potasium Carbonate	517	13	557	20	700	19	1,094	31
Potasium Chloride	1,528	15	851	9	1	14	2	21
Potasium Cholorate	2,319	65	2,001	62	2,946	98	2,538	78
Potasium Compound	2,663	24	228	11	336	12	354	16
Potasium Sulphate							23	194
Silica	1,287	67	1,183	65	1,467	82	1,543	92
Silicates	1,213	101	426	20	619	33	307	17
Silicon carbide	735	27	477	25	707	31	423	19
Silicon polymers	1,048	159	1,168	176	1,276	217	1,757	267
Soda Ash	3,700	26	3,033	22	5,746	43	25,631	177
Sodium bicarbonates	931	9	2,429	22	1,899	19	10,123	86
Sodium dichromate	82	4	1,054	49	1,375	70	761	34
Sodium Hyd. Sulphite	302	10	243	8	360	14	621	26
Sodium Hydroxide	4,373	50	1,307	26	4,415	69	8,854	126
Sodium Nitrate	1,458	18	770	11	814	12	1,182	15
Sodium Nitrate	101	1	270	4	1	11	1	12
Sodium Sulphides	12,859	146	6,213	66	1,193	38	873	25
Titanium oxides	1,605	135	1,505	135	915	84	2,140	218
Zinc Oxide	467	20	609	35	563	35	522	34
Mineral Based Chemicals	99,563	3,030	82,700	3,659	86,582	3,826	125,486	5,752
All Other Chemicals		46,000		54,000		58,200		71,300
Ores / Concentrates								7,200
Metals and Alloys								
(excluding Machines)								3,800
Mineral Based Products/Chemicals								16,752
TOTAL								**88.052**

studies, process-mineralogy for mineral beneficiation.

ii. **Mid term projects:** Geochemical surveys of economic minerals, such as base metals, precious metals (such as gold and platinum) mineralizations, rare earths in acidic and silica-deficient syenite rocks.

iii. **Long term projects:** Exploration for potential minerals, such as gold, silver, platinum group of metals, rare earths, nickel, magnetite, tungsten, molybdenum, lead- zinc.

MINERAL PROCESSING

Most of the ores, as mined, are not suitable for industrial utilization till undesirable impurities are removed. Suitable industrial processes were to be developed at PCSIR for upgrading every ore, first at the laboratory- scale and then at pilot-scale trials in order to establish its industrial viability.

PRIORITY AREAS FOR S&T PROJECTS

Some of the priority areas for S&T projects on the development and utilization of minerals, highlighted

Table - 2: Import of Mineral-Based Chemicals

Commodity	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)
Zinc oxide	1.1	16.7	0.9	15.1	1.1	17.3	0.6	10.7	0.6	13.6
Manganese dioxide	0.8	9.5	0.3	3.4	0.2	3.6	0.4	6.5	0.3	6.4
Iron oxide & hydroxide	3.4	24.5	2.0	24.1	3.4	38.5	3.4	30.7	2.5	40.0
Titanium dioxide	3.6	139.4	1.8	88.8	0.1	76.3	1.2	64.0	1.1	61.4
Litharge		0.5		0.2		0.1		0.4		0.2
Lead dioxide	-		-		0.1	1.4	0.1	2.2	0.1	2.0
Red lead	0.5	9.8	0.2	4.7	0.2	4.7	0.3	6.7	0.5	10.5
NaOH (Caustic soda)	4.6	49.8	2.9	33.0	11.6	133.8	17.2	175.7	20.9	162.4
NaOH (aqueous soln.)	-	-	0.1	0.1	-	-	0.5	0.5		2.0
Potassium hydroxide	0.2	3.4	0.3	5.1	0.1	2.6	0.4	7.3	0.3	6.2
Mag. Hydroxide	0.1	3.0	0.1	1.7	0.1	3.5	0.1	3.1	0.1	2.1
Al. hydroxide	1.8	21.9	2.4	29.4	3.0	30.7	2.8	30.1	4.5	43.5
Artificial corrundum	0.1	1.6	0.1	2.5	0.2	4.2	0.1	2.5	0.1	3.2
Hydrogen peroxide	8.4	94.3	8.7	98.5	9.6	117.2	12.3	154.9	13.6	189.1
Sod. Dichromate	1.7	20.8	0.7	14.3	0.8	20.2	1.3	28.9	0.8	19.6
Pot. Dichromate	0.1	0.8		0.5	0.1	1.1	0.2	2.4	0.1	1.1
Calcium carbonate	3.3	21.1	3.0	20.8	5.2	35.0	3.1	24.1	2.3	23.7
Sodium sulphide	9.1	47.1	9.4	61.9	9.3	62.2	11.9	77.4	9.9	61.6
Total		**464.1**		**404.0**		**552.3**		**627.9**		**648.4**

by various mineral-development agencies, are as follows:

i. *Coal washing:* Total estimated production of coal in ten years is 50 million tons. The cost of coal will increase from Rs. 750 - 7000 to 1500 - 2000 after washing. Ten percent of the total cost of production is taken as its economic worth, i.e. Rs. 50 billions.

ii. *Documented export of Gemstones* is Rs. 360 million, while actual export may be 4 billion per annum. The projected total output in 10 years would be about 40 billion, 20 percent of which is calculated as economic worth.

iii. *100 million tons of mine waste* cut-off and low-grade ores are generated. The cost at the rate of Rs. 10 per ton would be 1 billion/year, amounting to Rs. 10 billion 20% of which is Rs. 2 billion.

iv. *Rs. 35 billions of inorganic chemicals* are imported; 20% substitution from local resources in 10 years would amount to Rs. 7 billion as economic worth.

v. *Project cost put of Granite & Marbles* is expected to be 12 m/tons, worth 650 billion of finished products. The ceramic may be worth 20% of the cost i.e., Rs. 12 billion.

vi. *Bentonite clay* production in ten years period amounts to Rs. 5.0 billion rupees, 20% of which is calculated as economic worth.

vii. *Rs. 50 billion worth of iron ore* is required in the country in ten years; 20 percent substitution by this project makes economic worth as 10 billion.

viii. *On the basis of Rs. 5.0 billion Gypsum production* the economic worth is calculated at 20% i.e., Rs. 1 billion.

ix. *Magnesite chromite refractories worth Rs. 25 billion* are imported for cement, steel and other high-temperature furnaces. The projected fire-clay refractory demand is 250,000 tons/year, amounting to Rs. 5 billion in ten years. The economic worth is taken as 50% of the project i.e., approximately Rs.

12 billion.

x. The social, cultural, tourism, education and sale amounts to Rs. 10 billion as a rough estimate.

xi. Several small unexplored minerals exist in the country, which would also be developed.

UTILIZATION OF ECONOMIC AND INDUSTRIAL MINERALS FOR THE DEVELOPMENT OF CHEMICALS AND PRODUCTS

The focus can be placed on the following areas, needing immediate development:

- Mineral-based chemicals & products
- Value-addition of minerals by chemical/product
- Directly reduced iron-ore pellets for iron and steel
- Development of new materials and synthetic-mineral products
- The production of industrial chemicals, such as phosphoric acid; dicalcium phosphate and sodium acid pyrophosphate, from rock phosphate.
- Studies on the economic production of strategic chemicals/salts from indigenous ores of strontium, barium and magnesium.
- Preparation of industrial salts from indigenous raw material
- Materials-utilization of gypsum for production of sulphuric acid and salts
- Characterization of economic minerals, precious metals and gemstones of the country
- Beneficiation of graphite ore for the production of foundry-grade graphite concentrate.
- Development for toxicity-control of industrial products and waste managements
- Rare earths
- New building-material development, special materials for dams, saline and underwater application, processed sand with low alkalies, recycling waste in building-materials, such as cements, by using fly-ash, steel slag, etc.
- New materials, involving organic powder coatings, fillers, catalysts using cheap and natural environment-friendly materials.
- Development of Ferrite, cermets, ceramics from indigenous sources, such as beach sand containing zirconia, titania, monazite.
- Utilization of economic minerals and ores
- Value-added products from industrial minerals
- Clays as catalysts and environment-friendly materials.
- Coal utilization
- Mineral-based strategic chemicals

Table - 3: Import of Ores, Minerals and Mineral-Concentrates

Commodity	1989 - 90		1990 - 91		1991 - 92		1992 - 93		1993 - 94	
	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)	Ton (000)	Rs. (Mil)
Sulphur	27.2	66.6	23.5	62.8	24.6	81.4	43.7	58.0	30.3	47.6
Graphite Natural	2.6	11.9	6.0	19.3	2.8	13.5	5.1	22.2	1.9	11.4
Fluoraspar		0.2	5.1	15.0		0.1	2.2	5.5	3.2	18.2
Iron ore agglomerates	1,308	825	1,418.2	1,037	1,587	1,379	1,572	1,219	2,071	1,645
Alumina	0.5	6.5	0.7	8.1	1.3	20.6	0.6	10.4	0.6	1
Lead ore and concent.	0.3	7.0	0.3	5.7	0.3	6.7	0.4	9.5	0.2	6.2
Zinc ore and conc.										
Manganese ore / conc.	0.6	1.6	29.0	52.4		!	0.1	0.3		0.7
Titanium ore and conc.	0.1	0.8	0.2	3.0	0.3	3.0	0.2	2.3	0.2	2.5
Zinrconium ore /conc.		1.8	0.3	8.7	0.1	2.8	0.2	3.2	0.2	2.8
Rutile sand	0.3	4.2	0.3	5.0	0.2	3.0	0.2	3.9	0.3	4.9
Chromium ore / conc.	0.2	0.5				0.4		0.5		0.2
Coal	764.4	956	973.1	1,387	1,069	1,652	1,030	1,625	1,093	1,949
Total		**1,883**		**2,604**		**3,163**		**2,960**		**3,699**

Table - 4: Priority Areas for S&T Projects:
Estimates of Cost of Project and Economic Worth duirng ten-year period

(in million Rs.)

S#	Description	Cost of Projects	Economic Worth	Projected Total Output in Ten Yrs.
1	Establishment of Model Mines concept, regarding Coal washry, Coal beneficiation and Coal Banks in each province	0.435	50	500
2	Gemstone Training Institute: demonstration of Technology practices by inviting the foreign experts	0.18	8	40
3	Utilization of Mine-wastes e.g. Shale, Marble, Chromites, Coal etc. Regarding R&D work and extraction of valuables	0.435	10	10
4	R&D activities on products-development on industrial-based mineral, with special reference to Chromites, Nephelene, Syenite, etc.	0.495	7	350
5	Acquisition of technology for value-addition for Granite, Marble, etc., and R&D work on Building stones for local demand and export.	0.480	12	650
6	Investigation of Clay, including Bentonite Clay, and development of Barite closer to Karachi for mostly export.	0.460	1	5
7	Development of indigenous technology on Utilization of Iron Ores.	0.496	10	50
8	R&D Activities Gypsum and Anhydrite for commercial exploitation	0.075	1	5
9	Technology for refractory minerals, like Fireclay, Magnesite and Chromite.	0.425	12	25
10	Establishment of Museum of 1st Historical Geology for International Tourists of Quetta (Discovery of 1st Dinosaur Fossils, evaluation of whale, Human Evolution Fossils, Samples of Meteorites in Pakistan) & Strategraphic Museum of the world at Khewra George.	0.455	1	5
11	Up gradation / Strengthening of existing laboratories and human-resource development in the mineral sector.	0.3	1	5
12	R&D activities on mineral-based chemicals/ products .	0.5	1.6	15
13	Establishment of Geo-data centers. Geochemical studies for mineral Identification, resource and geological evaluation of base-metals as well as gold, copper, and platinum.	0.3		
14	Miscellaneous Projects Mineral Dep.	0.360	1	5
	TOTAL	**5.496**	**116**	**1620**

MINERAL-BASED CHEMICALS & PRODUCTS

The country needs large amounts of laboratory chemicals, which falls under the category of commercial, reagent, pure and analar-grade reagents. The pure and analytical grades of reagents marketed are not reliable, and the facilities available are sufficient to produce certified and standards chemicals, metals, materials and products.

In view of the increasing importance of environmental aspects, due to urban and industrial growth, new methods are required for recycling of waste, rivers and coastal-water preservation, safer and environment-friendly technologies, waste treatment, non-toxic catalysts and chemicals for industrial products, etc.

A number of strategic chemicals were being developed by the PCSIR, such as graphite, lead oxide, antimony metal, heat treatment salts, mould powders from Nepheline syenite, sodium phosphate. Other products of great industrial value have been produced on laboratory-scale, such as sodium cyanide, coated industrial minerals, electroplating salts, titania and alumina.

Huge deposits of all kinds of industrial minerals exist in the country, such as graphite, barite, calcite, magnesite, orpiment, celestite, trona, bauxite, talc, quartz, salt, vermiculite, phosphate. The value-addition of these minerals can easily be of great economic benefit to Pakistan, as it does not involve very sophisticated technology.

Although large deposits of economic minerals are not proven for their reserves, a number of small workings of lead, zinc, copper, alumina, titania, iron, antimony, Arsenic, Silver, Gold, Platinum, etc., showed the feasibility and good potential of these ore deposits. It was felt that a comprehensive project on the development of mineral products is a prerequisite for ultimate utilization of these deposits for local and export purposes.

It is estimated that about 100 crores rupees worth of Alumina, Iron and Titanium Industrial minerals are imported in the country, despite the fact that their reserves are abundantly available and the technology can be developed within low cost; some are developed at PCSIR at bench scale. The projects completed by geochemistry are Ziarat laterite, Bauxite from Khushab, red oxide, pigments and Nepheline syenite. There is wide application and demand for such products for use as refractories, abrasives, paints, pigmensts, catalysts, fuller in industries.Huge deposits of alumina and iron are available in the country, with varying grades and tonnage. A few of them can directly be employed for their particular purpose, while the others need specific processes/ methods for its upgradation to be made suitable for the particular industries. By developing the local technology, huge amount of foreign exchange can be saved at the same time, developing the indigenous mineral reserves of the country. Extensive reserves of a number of economic and industrial minerals and coal deposits are currently mined in Sind, Punjab, NWFP and Baluchistan provinces. Building-stones, granites, marble, seal salts, trona, china clay, bentonite, fullers earth, silica sand, celastite, calcite, marble, chromite, magnesite, manganese, copper, bauxite, zirconia, ilmenite, etc., are being mined in the provinces. As the GNP and per capita figures for minerals-sector is very small, application of the indigenous minerals in the development of conventional and New materials is required, through use of coordinated and systematic scientific method

VALUE-ADDITION OF MINERALS

Huge Deposits of Industrial minerals occur in the country, which can be exploited as basic materials for chemical Industry. New building-material for dams, saline and underwater application, processed sand with low alkalies, recycling waste in building materials; new materials involving organic powder coatings, fillers, catalysts, using cheap and natural environment-friendly materials. Indigenous materials for Ferrite, Cermets, Ceramics-development from indigenous sources, such as beach-sand containing zirconia, titania, monazite, etc. Heavy media preparation for drilling pigments.

DIRECTLY REDUCED IRON-ORE PELLETS FOR PRODUCTION OF IRON AND STEEL IN PAKISTAN

Pakistan is spending, on the average, Rs.2500 million every year on the import of iron and steel scrap to keep its remelting furnaces in operation. At the same time, the Pakistan Steel Mills is not meeting the per-capita requirements of iron and steel, which necessitates the

creation of additional capacity. The installation of Direct Reduction plants (200,000 to 400,000 tonnes per annum) seems to be a solution of both the problems i.e. huge foreign-exchange spendings on import of iron and steel scarp and the creation of additional capacity. This can be made possible by utilizing the small iron-ore deposits, which otherwise cannot be used for the conventional blast-furnace steel making.

DEVELOPMENT OF NEW MATERIALS/PRODUCTS

A large variety of minerals exist in the country, which can be modified for this specialised use. The R&D work in this regard will consist of evaluation, pyro-metallogenesis studies on the behaviour of natural materials for SO_2 pollution control. The manufacturing of mineral-based products, e.g. heat and wear resistant parts; fine ceramics, with their outstanding wear-resistant quality, textile parts made of zirconia materials and yarn guides from Al_2O_3.

STUDIES ON THE PRODUCTION OF PHOSPHATE CHEMICALS, SUCH AS PHOSPHORIC ACID, DICALCIUM PHOSPHATE AND SODIUM ACID PYROPHOSPHATE, FROM ROCK PHOSPHATE.

Pakistan inherits huge deposits of phosphate rock of good quality having P_2O_5 contents in the range of 24% to 29%. Thus, no dependence on foreign investment is involved at all. So far, no project for production of industrial chemicals has been undertaken and it is an entirely new attempt. The chemicals aimed at for production are in great demand in Food, Pharmaceutical, Beverage, Fertilizer, Metallurgical, Cosmetics, and Detergent industries.

STUDIES ON THE ECONOMIC PRODUCTION OF STRATEGIC CHEMICALS/ SALTS FROM INDIGENOUS ORES OF STRONTIUM, BARIUM AND MAGNESIUM

Utilization of indigenous ores of barium, magnesium and strontium, which have more than 90% of barium, magnesium and strontium contents. These rich ores, which are abundantly available in Balochistan, NWFP and Sind, would not only save foreign exchange but also create a nucleus for developing a chemical industry within the country. The main objective, however, is self-reliance in this specific domain.

PREPARATION OF INDUSTRIAL SALTS FROM INDIGENOUS RAW MATERIALS

Production of chemicals and industrial salts is a heavy industry that involves huge investment. The recovery of this investment is slow and this is the main reason that the investors are reluctant to invest in this domain. The economical and worthwhile route for the production is the resort to the use of minerals and ores that are locally available. However, the raw material for preparation of these salts is abundantly available in the market. Some major salts include sodium acetate, sodium citrate, table salt, iodized salt, potassium dihydrogen phosphate & sodium dihydrogen phosphate.

UTILIZATION OF GYPSUM FOR PRODUCTION OF SULPHURIC ACID AND SALTS

Gypsum of extremely good quality is abundantly available in Pakistan. Bulk is used as a material of construction, fertilizer and as filler. It can be used for the manufacture of useful heavy chemicals and industrial salts. Among heavy chemicals, sulphuric acid has special importance. At present, its production is based upon imported sulphur, involving huge amounts of foreign exchange. This important basic chemical, viz. sulphuric acid, can be produced directly from gypsum, which has a sulphur content in the vicinity of 25%. This sulphuric acid can be used for production of a large number of industrial salts.

PRODUCTION OF FOUNDRY-GRADE GRAPHITE CONCENTRATE.

This product finds application in making graphite crucibles, carbon brushes, lead pencils, lubricants, etc., and also in nuclear technology. Presently all the domestic requirement of this material (about 5000-6000 t/annum) is met through imports. Extensive deposits of graphite ore have been reported in the Malakand area of NWFP and Azad Kashmir. In ores of low grade and average, graphite content ranges from 10 to 20%. This can not be used, as such, without its beneficiation or concentration to make it usable as commercial market-commodity. The ore, after being crushed, ground and sizing, would be processed by the method of froth-flotation. Mineralogical studies shall also be carried out to choose the mesh of grind and for selection of flotation reagents.

Graphite and graphite-based products are imported to the tune of Rs.30-40 mil-lions/annum. Since the raw material is abundantly available in the country, its prdouction in the country would definitely save the foreign exchange spendings.

DEVELOPMENT OF MINERAL-BASED MATERIAL FOR TOXICITY-CONTROL OF INDUSTRIAL PRODUCTS AND WASTE MANAGEMENT

Mineral-Based materials have wide application in innumerable products of daily life, being easily available and cheap. On one hand, they have high priority for emerging industries while, on the other hand, they can

Box - 1: The Beneficiation Processes for Commercialization

1. Iron and Steel
   - i) Processing of Chichali Iron Ore
   - ii) Processing of Nokkundi Iron re
   - iii) Processing of Chilghazi and Chittral Iron Ore
2. Copper
   - i) Processing of Saindak copper ore
   - ii) Processing & leaching of Dir and Chitral copper
   - iii) Evaluation of Waziristan copper ore
3. Chromite
   - i) Processing of Malakand chromites
   - ii) Processing of Muslimbagh chromites
4. Lead/Zinc
   - i) Processing of Besham Lead/Zinc ore
   - ii) Processing of Dudder ore
   - iii) Processing of Azad Kashmir ore
5. Antimony
   - i) Processing & Recovery of antimony sulphide and metal from Chitral stibnite ore-
6. Laterite
   - i) Processing & Recovery of Iron, Alumina and Titania from Ziarat Laterie
7. Gold and Silver
   - i) Processing of Chilghazi Iron Ore for the recovery of gold and silver
8. Graphite
   - i) Processing of Azad Kashmir Graphite ores
   - ii) Processing of Malakand Graphite ore
   - iii) Production Foundry Grade & Pure graphite
9. Sulphur
   - i) Processing of Kohi Sultan sulphur ore
10. Nephylene Syenite
    - i) Processing of Koga ore for glass industry
    - ii) Processing for mould powder
11. Magnesite
    - i) Processing & Evaluation of Kumhar magnesite
12. Baryte
    - i) Processing & Production of Barium Chemicals
13. Manganese
    - i) Processing & Production of Manganese carbonate
14. Bentonite & Clays
    - i) Processing of Azad Kashmir Clays

Box - 2: Major R&D Projects of PCSIR for Commercial Development

- Mineralogical studies and beneficiation of Nokkundi iron ores
- Survey report on the mineral potential of Kohistan area
- Feasibility of the utilization of Pachinkoh Iron Ore
- Mining Feasibility and Processing of Nepheline syenite.
- Feasibility report on Chitral iron ore
- Feasibility of the utilization of Chigendik iron ore
- Mineralogical studies and beneficiation of Nokkundi iron ores
- Mining Feasibility and Processing of Nepheline syenite.
- Mineralogical Feasibility Report on Nepheline syenite for use in glass and ceramics raw material
- Metallogenic prospection for copper in Dir and Chitral Area.
- Mineralogical contribution in Pre-Investment Feasibility of Kel Graphite Deposit
- Feasibility of the utilization of Pachinkoh Iron ore
- Feasibility report on Chitral iron ore
- Feasibility of the utilization of Chigendik Iron ore
- Processing of Chromite on Industrial Scale. ADP Project
- Mining feasibility of Hazara Phosphate
- Production of flow sheet and pilot plant studies on Saindak Copper Ore
- Production of Quartzite Powders
- Magnesite for refractory
- Technical help in mine development for marble deposit
- Production of iron pigments Mineral based pigments were developed in the laboratory leased to party.
- Production of Red lead and litharge.
- Production of high purity graphite
- Recovery of talc from emerald bearing debris
- Antimony metal production
- Production of Rare earths, Radioactive minerals, phosphates and vermiculite from Carbonate
- Magnesite for refractory
- Utilization of chromite ore
- Mine development for Marble Deposits
- Decorative stone and marble requirement for export purposes are enhanced through R&D support
- Development of construction Engineering Mineral Based Materials
- Feasibility studies of the materials to be used for the construction of Dams
- Development of Sodium Hypochlorite
- Evaluation of antimony and tungsten deposits of NWFP in connection with the extraction of antimony metal. project.
- Washability studies of Coals of Punjab, Baluchistan, Sindh and Azad Kashmir
- Evaluation of gold-silver samples from Kaldam Gol area Chitral Processing studies were conducted on the Schelite ore from NWFP for the extraction of tungsten metal.
- Processing of carbonatite from Silai Patti area NWFP for rare earths and other elements.
- Processing of emerald bearing rocks of Swat area.
- Processing of precious metal bearing ores of Chilghazi, Baluchistan.
- Processing of Koh-i-Sultan sulphur deposit for the extraction of sulphur from the samples.
- Activation studies on the clay samples from various areas of the Punjab in connection with their utilization in ghee industries.
- Production of lead monoxide on pilot plant

Continue…

... Box - 2 Continued

- Development of strategic chemicals such as:
- Barium nitrate, Lead acetate, Lead nitrate, Potassium nitrate, Potassium chlorate, Lead Mono-Oxide, Cobaltous oxide
- Production of lead peroxide
- Research and development work on indigenous iron ores
- Research and development work on indigenous copper ores
- Processing of low grade chromite ores resources of Pakistan
- Separation of sphalerite and galena from lead zinc ore
- Processing of sulphur, magnesite, nepheline syenite, barite and antimony
- Indigenous gemstone valuation and processing for jewellery industry and precious metal winning and metallurgy required for Export increase programme of the GOP.
- Production of intermediate materials for chemicals, paints, paper, cosmetic & rubber industries from industrial minerals such as carbonates and silicates.
- Pilot plant studies for the production of disodium hydrogen phosphate and monosodium hydrogen phosphate from indigenous raw material.
- Development of electro-refining of copper on pilot plant.
- Studies on the economic production of strategic chemicals/ salts from indigenous ores of strontium, barium and magnesium.
- Extraction of strategic metals from indigenous resources.
- Processing of industrial minerals like fluorite and barite ore for commercial exploitation.
- Utilization of indigenous low quality cost and smokeless briquettes for industrial use.

play a vital role to control the demanding future problem of industrial and urban pollution.

Catalytic activity of Pakistani clay-minerals for friedel-crafts akylation: The majority of the catalysts used by organic chemists are based on naturally occurring clays and minerals. The catalysts marketed by various chemical companies prepared from the clays and minerals available in their country. The natural clays or minerals also find use as a catalyst-support and also suitable catalyst for the conversion of larger molecules. The clay-supported reagents are known as pillared clays.

It has been observed that montmorillonites exchanged with the Fe(III) ions is effective for a variety of Diels Alder reactions and for chlorination. The transition metal atom present in natural clays is thought to be the seat of impressive and varied catalytic activity. Recently, the activity of natural clays as catalysts for Friedel Craft alkylation has been investigated. The clay composition and structure changes with the change of source and no two clays are identical in all respects.

The use of alumino-silicate as catalyst in various organic synthesis is most environmentally sound because of ease of handling, work up, non-corrosiveness and low cost.

RECOMMENDATIONS

In view of the requirement of mineral-based industries, the sustainable development in mineral utilization is promising on account of the occurrence of mineral-resources and availability of basic exploration and R&D work conducted by different organizations. However, serious constraints in HR, developmental capital, paucity of funds, lack of commercial ventures, international competition, lack of integrated approach in mineral-development between experts, coordination of earth scientists, technologists, business and management all need attention.

Identification of priority areas and strategies of development from different perspectives are required through relevant specialists. (An example is highlighted in this paper).

Integration of efforts in mineral development is hitherto missing. The projects should not merely result in generation of a report or creation of infrastructure, but should result in business-generation and commercialization.

Technology business incubation may be practiced as a mechanism to promote the commercialization, to reduce cost of investment, increase the success-rate by pilot-scale production through risk coverage, integration, networking, sharing of information.

To overcome the scarcity of qualified and experienced professionals, pools of mineral scientists, technologists and engineers may be created for planning and developmental work, involving all the disciplines.

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