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PRESIDENT'S COLUMN

In Bulletin's December 2007 issue (Volume 8, No. 2) considering depletion of high grade iron ore resources at a faster rate, necessity of conducting explorations for proving additional resources and importance of R&D efforts for technological improvements to utilize low grade ores were emphasized.

In the advent of Global recession and its impact on iron and steel sector, the industries in India adding value to iron ore i.e. sponge and pig iron units have been adversely affected. Now export has become virtually negligible. Substantial reduction in demand of iron ore has brought down the production in most of the mines.

As expressed by financial experts and economists, this recession will have less impact in India for a shorter duration, when industrial and economic growth will continue at a slower rate. Whatever may be the projections for future, it is the right time now for taking up measures for future growth.

All efforts should now be made by the Government exploring agencies jointly with the owners of the concessions to undertake modern exploration techniques to reassess the iron ore resources in two categories i.e. directly usable grade and to be beneficiated grade. Our Society is organizing a Seminar on **Iron Ores – Genesis and Exploration Techniques** in December 2008. The deliberations by the experts shall no doubt assist in projecting various modules for exploration to be carried out and to assess the potentiality of the iron ore deposits. Assessment should focus on the extractable resources excluding non mineable resources located within environmental fragile zones.

It is also time for mining sector to consolidate its activities and plan for future giving stress for technological improvements, infrastructure developments and large scale eco-friendly operations preferably in clusters to make the raw materials available for the mineral based industries at low cost, so that the value added industry and the total mineral sector in India becomes competitive in the world market.

Dr. R.C. Mohanty
(President, SGAT)

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CURRENT SCENARIO FOR IRON ORES AND THE INDIAN PERSPECTIVE

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Abstract

The vibrant story of the Iron Ores today can be said to have commenced from 1991, after a long spell of quiescence with a production status quo almost stay put. The ore demand grew by leaps and bounds with exponential rise in industrial production of iron and steel all over the world. In fact, the record high of 1.5 Billion Tonnes of iron ore in global production was achieved in 2006 and the trend is on, though with numerous patches of intermittent unsteadiness. 48 countries are active ore producers while 64 countries are busily engaged in steel making. Indian ore came from 281 active mines in 2005-06 and ore raised totaled at 154 Million Tonnes, sizing up independently to calendar years of 2005-06 at 146 MT and of 2006 at 169 MT, estimated to reach 172 MT by 2006-07. World order position of India has been within the top 4 producing countries, e.g. India, China, Brazil and Australia. Global trading reached a record level of 822 MT in 2006-07 with the Indian share hovering ahead of 94 MT. Sea-borne trade in the world reached an all time high of 711 MT in 2006 and the sky-rocketing price contracts of 2007-08 are certainly going to jack it up. The Indian scene, according to an estimate, shows the production cost of ore per tonne at site around $7/-, when the international selling price is well beyond $45/-.

Iron Ore scenario of the globe is dominated by 3 firms, Vale Inco(Brazil), Rio Tinto(now Canada) and BHP Billiton(Australia) controlling 35% of the market. Amidst leaner players, Mergers & Acquisitions for consolidation and greater hold, have taken a fast hop since 2004-05. The Indian panorama is highlighted with Arcelor-Mittal and Tata-Corus rising at the horizon. Numerous new mining projects are on and a recent UNCTAD report states of 375 MT new production capacity round the world is likely to be on board by 2007-2009. Resource position by USGS estimates, stood at 160 BT "Reserve" and 370 BT "Reserve Base" for the whole world as in January 2007. India in this spectrum stood at 6.6 BT and 9.8 BT respectively. NMI data for India as on the 1st April 2005 however registers the combined hematite-magnetite balance of reserves now available at 18.2 BT. Projecting India's growth of steel requirements in the foreseeable future and vetting against negative parameters like poor recoverability factor in iron ore mines, likely great leaps in future export needs ,chnacey lack of surety for unabated needs of iron ore in posterity with possibilities of substitution and newer innovations; heady conservation schedules or regulating optimum production etc., look like questionable preambles for a realistic and achievable future planning The real necessity is for vigorous exploration and exploitation, matching domestic ore-feed dosages of upward revision, massive export commitments, value additions as well as infrastructure developments and above all; a far-sighted thoughtful laying out of a sequential plan envisaging commensurate precision with perfect timeliness in the swift and unfailing execution with high priority.

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The Iron Ore Boom

After a longish decadent hibernation for the iron ore demands all over the world in the seventies and eighties of the last century, the nineties became a mute witness to the sinuous upsurge of the demand curve. In fact, the last decade underwent a blooming upturn in its overall growth, going upto 5.3% or so, going by the Ruskill Metals &

Mineral Reports. Phenomenal upswing in the World production of iron ore resulted in a record turn over of 1 Billion Tonnes by 2002 and 1.5 Billion Tonnes by 2006, a 5th consecutive all-time high. While most of iron ores are used in the metal extraction suitable for the Steel Industry, a significant part goes into partial end products such as Merchant Pig Iron [91-94%Fe, 3.5-4.5%C, O.25-3.5%Si] and Direct - Reduced Iron or DRI [90-94%Fe], due mainly to, progressive downtrend in the availabilities of scrap steel resources. It may be worthy of mention that India is the largest producer of DRI, which really exceeded 14.7 Million Tonnes in 2006. Incidentally, global crude steel production of 2006 stood at 1,240 Million Tonnes, Pig Iron at 871.5 Million Tonnes and DRI at 60 Million Tonnes.

Globally considered, 64 countries today are engaged in production of crude steel, while 48 countries cover the list of major producers of iron ore. Available data on world statistics of annual iron ore production, records a total of 1,163,770,000 Tonnes in 2003, as per the United States Mineral Resources Program publication in "Search Index Mundi.

The available production figure for the financial year 2005-06, from the then existing 281 mines, by the records of the Indian Bureau of Mines, registers it as 154,436,000 Tonnes of a value equivalent of 86,905,259,000 Rupees. Asia happens to be the largest producing region, followed by South America and Oceania, where in, China, India, Brazil and Australia represent the largest ore producers of iron ore, in the same quantitative order. Calendar year computations authored by Jose Paul (Ex-CMD, Marmugao Port Trust) and published in The Hindu Business Line of 19th March 2007, shows the annual Indian production of 2005 as 146 Million Tonnes and of 2006 as of 169 Million Tonnes. A recent web document, "Demand-Supply Management of Iron Ores for Steel Industry" by A.K.Pandey. General Manager(CRMG) of Steel Authority of India(Sept'08) has figured out the Indian production of iron ores in 2006-07 as 172 Million Tonnes.

Production & Exim

Since the needs of iron ores are linked to the growth of demand for iron and steel, nay the growth of classic steel industry, both in domestic sense and export needs abroad, the business needs are compelled to go by the inherent profit considerations in both the sectors. Production costs at mine sites have been evaluated as Rs.300/-{$7/-} per tonne against the international selling prices hovering around $45/- per tonne Contract prices are estimated to increase very heavily, some 65% to 87% over the 2007 base price. International trade has reached a record level of 822.4 Million Tonnes for 2007, with the Indian export reaching up on 94 Million Tonnes, thus becoming the largest exporting country, ahead of South Africa, Canada and Russia. Of course, China continues to be the largest importer, gulping down 383 Million Tonnes, i.e. nearly 46% of the total iron ore imports for all the countries of the world; in spite of being even one of the largest producers herself. Sea-borne trade is the main sustenance for international marketing and is bound to rise exponentially in coming years, irrespective of freight rate increases. The sea-borne trade, as per the "The Iron-Ore Market

2006-2008" from the United Nations Conference on Trade & Development(UNCTAD), reached an all-time high of 711 Million Tonnes in 2006 and is bound to rise sharply, notwithstanding the severe freight elevation in rates of 2007. 2008 is ostensibly peaking up as expected, commensurate with trading jack-ups, both in quantity as well as spread of the area of operation.

In spite of steady efforts of consolidation in the Iron Ore Industry since the Seventies, the most visible Mergers & Acquisitions(M&A) processes have gained ground almost from 2004-05. The biggest three, viz. Companhia Vale do Rio Doce or CVRD of Brazil, named as Vale Inco from 2007, with Rio Tinto& BHP Billiton of Australia control 35% of the global market. The M&A continuity into 2006-07 has yet shaped bigger corporate housel like Arcelor-Mittal and Tata-Corus, which have developed interest both in the ore mining as well as metallurgy segments of Iron & Steel. Besides with expansion of steel mills, mining capacity is being stepped up and alongwith it, naturally the network of captive mines. UNCTAD supports of an estimate of new projects to the tune of 375 Million Tonnes of new production capacity by 2007-2009. The world picture for iron ore needs is therefore, an ever-increasing rhapsody and India too is no exception., into this musical alarm participating within this growing demand phenomenon round the globe; yet one has to rest with the volatility of the market fluctuations for iron ores and hence the inbuilt uncertainty with it to a large extent – a factor to be consistently warned about for preparation even in the worst scenario.

Resource Round-up

With background of the ore production and demand scenario as foretold, endowment size often becomes relevant for judging the parity propositions. Resource position as tabulated by the United States Geological Survey in "Mineral Commodity Summaries, 2007"; projects the figures for 'Reserves' and 'Reserve Base' for estimated global Iron Ore deposits respectively as 160,000 Million Tonnes and 370,000 Million Tonnes, where in, the Indian positions correspondingly are marked as 6,600 Million Tonnes and 9,800 Million Tonnes. Against this overall backdrop, a more accurate picture in the Indian context emerges with the following data [in unit of Tonnes] from National Mineral Inventory as on 01.04.05, as follows:

Ore Mineral : Type	Balance of reserves now	Total reserves original
Iron Ore [Hematite]	7,626,220,000 Tonnes	14,630,388,000 Tonnes
Iron Ore [Magnetite]	10,560,977,000 Tonnes	10,619,481,000 Tonnes

Remarks: Cut-off grade for hematite resources taken as 55%Fe

Totality of the original estimates of reserves being a meaningless exercise as the mined out portions, do not exist for projections any longer.. Careful addition of the total available iron ore reserves of hematite and magnetite, taken together as at present, gets on to show that about 18.187 Billion Tonnes of ore are left in to meet the domestic requirement of 110 Million Tonnes of steel making, as planned by the Ministry of Steel of Govt.of India, for 2010 and beyond; say for 100 years thence. This assumption is a gross over-estimate as it unduly presupposes

1. Total recoverability of this ore, despite mining/recovery losses, despite
2. Long term export commitments and despite
3. Any future compulsions for curtailing and selectivity for intradeposit / intramine areas of physico-chemical unacceptability etc. and
4. Last of all, with an undue futuristic optimism of nonsubstitution for steel in long terms, through nano-technological advancements to titanium and/or aluminosilicates or through any propylene-acetyl substitutes and so on.

Our experience is already there in mineral industry, where natural mica is getting replaced by the synthetic, manganese ore for steel is being much less required with elemental substitution and dolomite/magnesite in the blast furnace being much replaced with dunite – peridotite - pyroxenite types of ultramafic igneous rocks, accepted as mining waste hither to, in the chromite ore mines of India. The future need not be just a stereotype repetition of the status quo in this modern world of daily advancements of science and technology.

Supply-Demand Compatibility

The UNCTAD document mentioned elsewhere, clearly indicates a chance of oversupply position for the iron ores all over globe by 2009. The Federation of Indian Mining Industry(FIMI) in their report entitled "Indian Iron Ore" circulated in the internet by 2008 too, have cautiously remarked of (1) the possibilities of glut in domestic production not required for the domestic Iron & Steel industry and of (2) likely imbalance in regional surpluses not having enough domestic outlets, mostly raised through noncaptive mines. The production figure of 2006-07 of 172 Million Tonnes, the domestically consumed quantity of 56.28 Million Tonnes and the exported amount of 100 Million Tonnes(quoted from SAIL Report of A.K.Pandey in website), may just show a marginal surplus but even 2008 trends do not concur with same vision. A reliable financial analysis by Reuters website report of 21st January 2008 has revealed that at least, 20-25 Million Tonnes of iron ore deficit in the world in this year of 2008 it self, seems definitely unavoidable in the world. Added to this, the most recent Govt. of India announcement in connection of holding inflation etc.(Times of India of 13th September 2008); clearly states of likely ore shortage for the domestic steel plants and hence proposes to enhance export duty to 20% to discourage export and effect consequential reduction and thence break even with the internal demand. A most recent statement by the Central Minister of Steel, Sri Ram Vilas Paswan at Bhubaneswar, has clearly spelt out of the fact that:

1. only 6% of the country's demand of steel is being produced within,
2. original steel target for 2020 at 124 million tonnes, is getting revised to the same figure hardly by 2011-12, and
3. the steel production in India by 2020 could reach 300-350 million tonnes.

The distant future may not be as brilliant, say after 30 to 50 years hence, if steel continues the ruling status amongst the mostly used metals for humanity as of now. Population (India today at 1.2 Billion) would increase and per capita needs (India today at 38 Kilograms) too must grow for improving quality of human life. Increasing needs could raise the tempo of production yet higher in all probabilities but the moot point will be on whether or not adequate exploration is being carried out and newer reserves established. India stopped detailed exploration for iron ore by the largest governmental agencies like the Geological Survey of India and Mineral Exploration Corporation for 2 decades towards the end of the last century and even after that, the exploration revival has not yet taken a war footing, such as in many other countries of the world, to identify new iron ore deposits, to quantitatively establish the detailed geological parameters or to evaluate mining feasibility etc., in any large scale manner. Leaving countries like Brazil, Australia and like, developing nations like India, seem to look fairly complacent with a short-sighted tunnel vision, corroborated through the remark of an once-upon-a time Joint .Secretary of Ministry of Steel, proclaiming in January'05 and reported in JPC Bulletin on Iron & Steel, 2005; of India's adequacy in proven iron ore reserve for 200 years at least. Never could be a more erroneous perception get ever presented to the public from any responsible source. It is time to look beyond the present or near-present scenario in a long term perspective., if our generations would have to live as well as we would like them to be upto, getting out of the complacency shell, we have put over ourselves mostly bereft of the direct knowledge of actual situations and hurriedly concluding over meager data within the means of our incomplete wisdom perhaps.

A strong domestic demand too must be created to the extent possible, for neutralizing regional imbalances, through steel mills rolling out the hot metal in as many areas of the country, as possible within a reasonable short time, lest we miss the bus in competing with the whole world. But a steel mill does not stand up with iron ore adequacy alone. Dire needs of many other raw materials and facilities, may not be suitably available in many locations throughout the country. A steel-mill entrepreneur has to take the decisions entirely on the points of economic merits and viability anticipations. Our perspective planners have to be equipped with this reality status rather than going ahead with emotions and often biassed regional feelings, as the guiding factors for site decisions. Build up of strong internal demand for iron ore within the country, even bypassing the construction of steel furnaces ad infinitum or stretching out the export sector yet further; can not be derived without governmental involvement- not only for industry building alone but for infrastructural growth also; taking cue from the recent case history of the sky-rocketing growth in the case of China. Somewhat the same is the case with South Korea and Japan, where infrastructural development has gone practically concomittant with industrial advancements like steel factories as well as their ancillary satellite industrial ambience. India must take advantage of her great positions, both by virtue of established resources as well as the likely additions which look available with proper orientation of exploration, from geoscientific considerations of geological potentials. The production, consumption and export together with the present day DRI prowess; have to match sufficiently with the world demand and advance planning of men, money and materials which make the swiftest aids to resource rising as also their scientific exploitation, totally keeping eyes on the aspects of conservation and innovation. The breakthrough must step in within the next 20-25 years.

Last but not the least, it must be also mentioned that the current Indian mining climate is so much bogged down now with snail-speed Mining Lease renewals and new grants, unlimited waiting for forest and environmental clearance, impromptu incentives for value addition to the plentifully generated iron ore fines, both as natural matters and tailings. When shall we look forward to instant amelioration?

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STEEL PERSPECTIVE

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INTRODUCTION

Though several alternative technologies of iron making have emerged which may find acceptance in future, the BF – BOF route of hot metal production will continue to dominate the iron making process. This is because of BF-BOF process has continued to remain most up-to-date and competitive, through innovative developments, which have contributed to improve design and engineering as well as improved process efficiency. In addition to this, many new technologies have developed to use iron ore pellets, fines and concentrates in EAFs and IFs – especially in India.

In India the cost advantages of availability of Iron Ore and cheap labour is neutralized by the high cost of coking coal and low labour productivity and does not translate into international competitiveness which is the areas of concern.

There is a need for steel industry to prepare for a highly competitive environment, both to survive as well as to attain its objectives of growth.

IRON ORE RESOURCES

India's massive deposits of Iron Ore provide great impetus and support to its steel industry's growth. India possesses 6% of global reserves and is the fourth largest producer. Iron ore resources are mainly concentrated in the states of Orissa, Jharkhand, Chhattisgarh and Karnataka. (Table – 1). This explains the preference of the investors to set up new Greenfield projects in these states.

The national steel policy has projected total iron ore requirement of around 190 MT per year in 2019-20, based on the assumption that new steel production capacities will be 60 per cent through BF route, 33 percent through sponge iron-EAF route and 7 percent through other route. Thus, the cumulative iron ore requirement for the country till 2019-20 shall be around 2.0 BT (taking 2004-05 as the base year).

Table – 1
The present availability of iron ore in India

State	Iron Ore Reserve (2004) in million tonnes		Total (million tonnes)
	Hematite	Magnetite	
Andhra Pradesh	89	1309	1398
Assam	-	4	4
Bihar	-	-	-
Chhattisgarh	2278	-	2278
Goa	729	188	917
Jharkhand	3281	8	3289
Karnataka	1315	3844	5159
Kerala	-	39	39
Madhya Pradesh	152	-	152
Maharashtra	273	1	274
Orissa	4177	-	4177

Rajasthan	20	1	21
Tamil Nadu	-	2	2
All India Total	**12314**	**5396**	**17710**
Source: Indian Bureau of Mines, Nagpur			

Zone A in Jharkhand/Orissa consists of large deposits at Chiria, Thakurani, Malangtoli and Gandhamardan deposits.
Zone B in Chhattisgarh contains Bailadila and Rowghat iron ore deposits.
Zone C in Karnataka state has deposits of Kumarswamy, Ramandurg and others.
Zone C & D are of lessor importance in Goa, Andhra Pradesh and Rajasthan.

PIG IRON PRODUCTION

Industrially, iron is extracted from its ores (Hematite & Magnetite) by a carbothermic reaction (reduction with carbon) in a blast furnace. Even today, more than 90 percent of iron production in the world comes from the classical Blast Furnace (BF) route. Iron ore agglomerates like sinter/pellets, fluxes and coke are the key input materials for the BF process, which has been the unchallenged method of making hot metal on a large scale.

However, the world is witnessing a gradual shift from the integrated steel plants using the BF-BOF routes to relatively smaller plants or mini-mills based essentially on EAFs, with alternative means of producing iron coming into vogue to complement the BFs. New methods like DR (Direct Reduction) and SR (Smelting Reduction) have been developed to provide the feedstock necessary for EAF steelmaking which earlier used scrap. These technologies though ahead of BF in terms of versatility and environment friendliness will take time to gain popularity. Whatever the process the emphasis will be on "increase of productivity" and "efficiency in operations".

It is however essential that a proper strategy be adopted to further promote alternative technologies in India. Wide scale adoption of any technologies will depend on sustained availability of the required raw materials – high grade iron ore and reductant in the form of non-coking coal/natural gas. Non-coking coal for rotary kiln operation is not always readily available – beneficiation of lower grade coals or import of low ash coal may become necessary in the long run. Similarly, natural gas offers considerable promise since it is an excellent reductant for "green" steelmaking. To make this a reality, natural gas needs to be exploited in the years to come for direct reduction on India's high grade iron ores. At the same time, to ensure long term supplies of the required grade of iron ore, beneficiation of lower grade ores, particularly fines, needs to be encouraged. The final input would then be pellets since the concentrate produced would required pelletising before use.

Hot metal is the iron produced by reduction and smelting of iron ore in Blast Furnaces. Basically, BFs produce hot metal in "basic grade" for steelmaking and "foundry grade" for production of castings. Pig iron is an intermediate step on the way from iron ore to cast iron and steel. Growth in production of pig iron has increased by main producers as well as secondary producers and has been quite substantial in the recent years. This trend is likely to continue. The state-wise units of secondary production is placed in Table – 2.

Table – 2
Statewise capacity & production of secondary producers of Pig Iron during 2005-2006 ('000T)

State	No. of Units	Capacity	Production	
			Hot Metal	Pig Iron
Andhra Pradesh	2	270	246	245
Chhattisgarh	3	643	756	520
Goa	2	345	342	325
Jharkhand	1	200	203	10
Karnataka	3	680	726	357
Maharashtra	3	4817	3805	104
Orissa	3	1445	954	879
Tamil Nadu	1	245	248	16
West Bengal	4	687	601	582
Non Reported (Estimated)	10	1000	650	650
Total	**32**	**10332**	**8529**	**3688**

Source JPC

STEEL SCENARIO

The world production and consumption of steel has considerably increased during last 6 to 7 years. This trend is also observed in India where the main producers as well as secondary producers have equally registered growth.

Keeping in view the latest trend after the slowdown from mid 2008, correct forecast can't be made for the future. In future, there will be more awareness for the need for nationalizing production. In the commencing years most of the productions will be the hands of few top producers. Projects undertaken by the steel majors within the country (Table – 3) and their progress is to be monitored which could indicated the future growth of the sector.

The technology to manufacture steel also will have to progress in view of potential scenario and particularly, semi finished steel products will be made in countries where energy and ore are available at competitive costs. The thrust will be on energy saving in blast furnace, EAF and hot charging (rolling) and specialized high capacity plants with compacted production phases.

The salient features of Indian Steel industry today are as under: -

- An area of concern is non-availability of coking coal
- India is comfortably placed in respect of Iron Ore, Fine ores have to be utilized for pelletisation or sintering.
- The major problems facing the steel industry is pollution/environment controls.
- The steel industry is now exposed to new challenges in the form of tough competition for which is needs to change the work culture with maximum emphasis on cost reduction and in improvement in quality of products.
- Cost competitiveness will be come from operational efficiency which in turn will depend upon:

  Quality & cost of raw materials
  Cost of energy
  Technology
  Logistic and Infrastructure

For competitiveness, Steel Industry also will have to:

- Make investments to upgrade technology to face highly competitive markets
- Achieve value – added production in a cost effective manner and maximum value addition through backward & forward integration
- Enlarge its quantitative marketing base by orienting product mix to suit markets
- Adjust production to meet changing market requirements
- Obtain higher flexibility and quicker response time for customers and extensive customer contact.
- Undertake aggressive marketing with flexible pricing.
- Provide better after sale services and boosting of exports to relive pressure on domestic market.
- Forge strategic marketing alliance

ORISSA SCENARIO

Orissa has been a favoured destination due to: Mineral resources, Investor friendly destination, Availability of power and Abundant water resources even though infrastructure and industrial culture has been poor.

Today, in addition to existing and gone-into-manufacturing plants, several major projects and still under implementation. However, the pace of implementation is extremely slow due to:

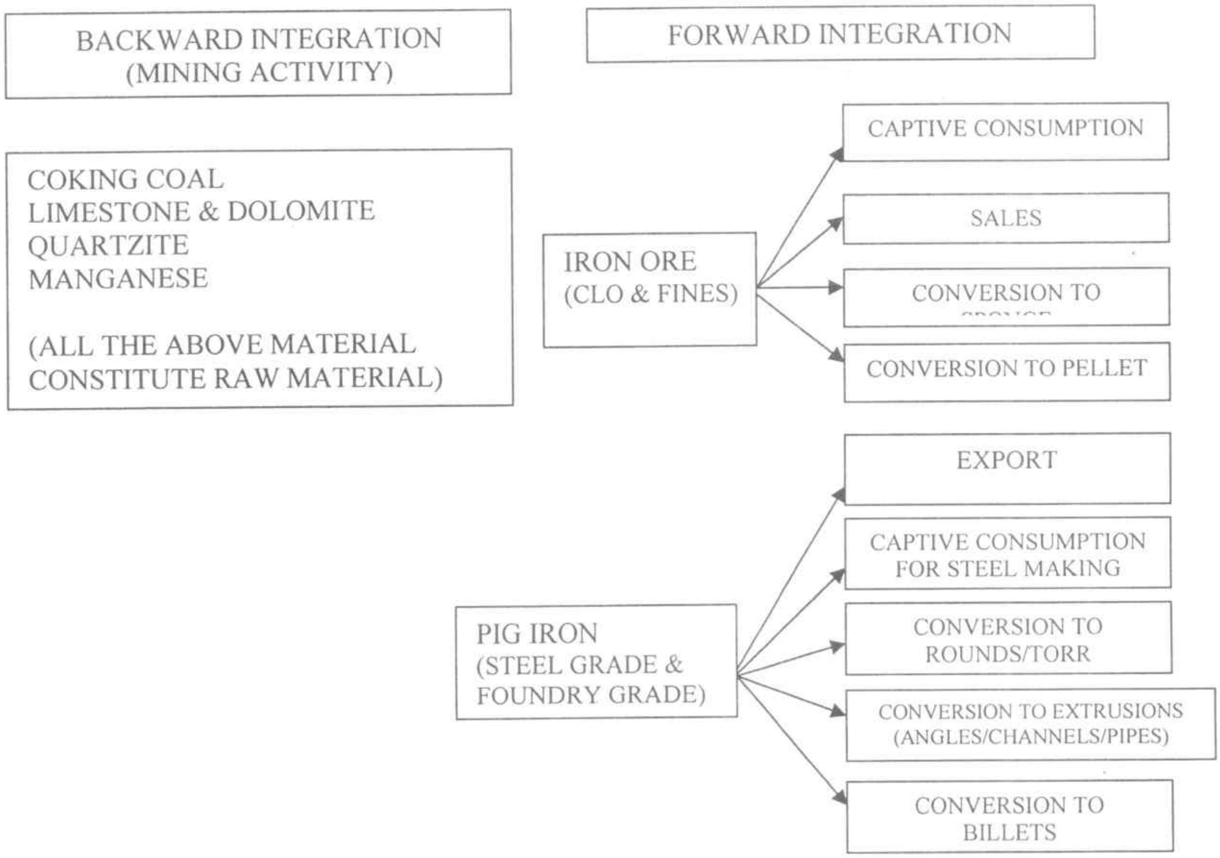
- Capacity building not being in tandem with raw material linkage, availability of land
- Poor infrastructure
- Poor law and order situation
- No industry specialists in state planning, development and promotional agencies to understand industry needs
- Bureaucratic interference, redtapism and backtracking in state commitments.

Having been gifted with huge mineral resources, the State Government should accurately assess the value addition opportunities thrown up by the iron ore mining and steel making industry, some of which are presented in Exhibits 1 & 2 below.

The steel industry will be the prime mover for Orissa's growth and development. Hence, the State must put in motion a perspective plan, act and demonstrate their commitment to support growth. Steps to be taken are:

1. Action plan for the future by creating a mindset and definite agenda to enhance growth. Professionals from the industry should be involved in this process.
2. Create public awareness about the benefits of project to prevent public, social and political oppositions/resentment.
3. Create the required infrastructure facilities of road/rail/port, water, power and access to raw materials for the industries and ensure availability of land.
4. Ensure the preservation of environment and eco-system.
5. Seriously look into all possibilities and move to new areas of value addition through backward and forward integration as future sustainability will hinge on this. Also encourage the promotion of ancillary and down stream industries.

<u>**EXHIBIT – 1**</u>
VALUE ADDITION – IRON ORE & PIG IRON



<u>**EXHIBIT – 2**</u>
VALUE ADDITION – STEEL MAKING

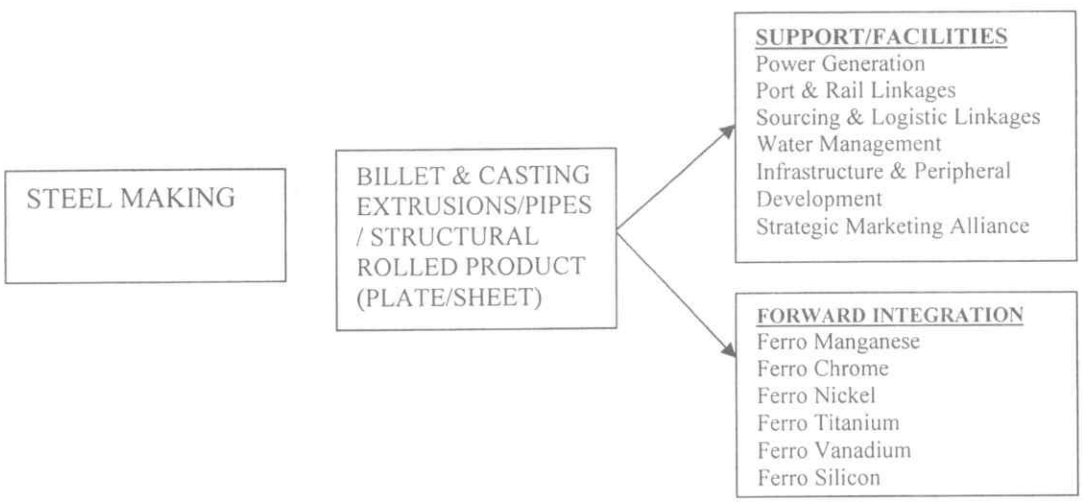


Table – 3
Expansion projects undertaken by Steel Majors

Company	Capex (Rs. Cr.)	Location	Expansion Project	Time Frame
Tata Steel	70,000	Jharkhand	12 MTA ISP in Mahoharpur and Chandil areas	First phase to be completed within 36-54 months of obtaining all clearances
		Jharkhand	5 MTPA addition at Jamshedpur to take total capacity 10 MTPA	First phase of expansion to 7 MTPA underway to be completed by 2008
		Chhattisgarh	5 MTPA ISP in Bastar	First phase to be completed within 48-60-54 months of obtaining all clearance
		Orissa	6 MTPA ISP in Kalinga Nagar	First phase of 3 MTPA underway, to be completed by 2008
		Orissa	25 MTPA deep water port in Dhamra alongwith L&T, 62km private rail link between port and South Eastern Railway network	Port to commence operation from December'07
		Tamil Nadu	60,000 TPA Titanium dioxide plant, 1 MTPA ilemnite (Iron Titanium Oxide) plant in Tuticorin.	To commence operation in 2007
		Iran	3 MTPA gas-based steel plant with provision of scale upto 5 MTPA	To be commissioned in 36 months after start of work
		Australia	4 MTPA coal mine in Queensland	Operations to start in 2007
		Bangladesh	2.4 MTPA steel plant in Western Bangladesh, 6-7 MTPA coal mine in Dinajpur	No definite time frame
		South Africa	0.135 MTPA ferro-chrome plant in Richards Bay	To be completed in 17 months from groundbreaking
JSW	35,000	Jharkhand	10 MTPA steel plant and 800 MW power plant in Hesalong	To commence operatins by 2010
	5,000	Karnataka	2.8 MT addition in Vijayanagar	To be completed by mid 2008

Essar Steel	6,500	Gujarat	3.9 MTPA steel plant in Hazira	To be implemented by June'2009
	2,000	Gujarat	1.6 MTPA addition in Hazira	To be completed by 2007
ISPAT		Maharashtra	0.8 MTPA addition by debottlenecking and 1.2 MTPA addition by setting up new EAF at Dolvi	No definite time frame
	800	Andhra Pradesh	3 MTPA pellet plant in Visakhapatnam	To be completed within 30 months from zero date
SAIL	1,553	Tamilnadu	0.18 MTPA stainless capacity and 65,000 TPA CR capacity to be added at Salem	To be completed in 36 months
	166	Jharkahand	0.5 MTPA mine development with Bharat coking coal	No definite time frame
	6,000	-	Various expansion and modernization – projects at SAIL and mines	Currently under implementation, no definite time frame
	9,592	West Bengal	Expansion at IISCO steel plant	No definite time frame
	738	West Bengal	0.7 MTPA bar and rod mill for Durgapur Steel Plant	No definite time frame
	593	Jharkhand	Upgradation of Blast Furnace and Coke oven battery at Bokaro Steel Plant	No definite time frame
(Indian A & Ms: Mittal – Arcelor, Tata-Corus, Essar-Algoma) (Source Economic Times Intelligence)				

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MULLITES FROM CLAY AND PARTIALLY ALTERED KHONDALITE

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ABSTRACT

Mullite has been prepared from two raw materials available in Eastern Ghat Group of rocks, India. Partially altered Khondalite (PAK) from bauxite mine and clay from an adjacent area, were individually mixed with appropriate alumina powder and processed in a thermal plasma reactor for mullite preparation. Quality of mullite from both the samples was evaluated through their physical, mineralogical and breakage properties. Mullite from both the feed is found to be suitable for refractory application.

Key Words: Partially Altered Khondalite (PAK), clay, mullite, plasma reactor, breakage characteristics.

INTRODUCTION

NALCO is presently mining about six million tonnes of bauxite from Panchpatmali plateu per annum. Once the bauxite is removed, the Partially Altered Khondalite (PAK) - the host rock, remains as waste. As it contains some clay minerals, attempts have been made at Institute of Minerals and Materials Technology to convert it to value added products (Bhima Rao et al, 2006 and Project report, 2007). Mullite, which is used in high temperature applications, corrosive environment etc., rarely occurs in nature. Efforts were made to prepare mullite from PAK and clay from adjacent area which is not used at this moment. These products were characterized morphologically, mineralogically, chemically and physically to access their quality for refractory application. The paper describes the characteristics of both feed materials and suitability of mullites prepared from them, for industrial applications.

MATERIALS AND METHODS

Raw materials

The partially altered khondalite (PAK) was collected from Damonjodi mines of NALCO bauxite deposits. These deposits are located in Panchpatmali plateau, Rayagada, Orissa. The clay sample was collected from a similar geological set up (Eastern Ghat Groups) located at Andhra Pradesh. Commercially available alumina was procured to add with both the types of raw materials to get proper composition of mullite.

Preparation of mullite

Preparation of mullite from PAK and clay sample was similar. PAK fines and commercially available alumina were thoroughly mixed in a ball mill for one hour to obtain a homogenous mixture. The mixture was palletized with addition of PVA binder and oven dried to remove moisture. Experiments were carried out on these pellets to prepare mullite in an indigenously developed extended arc thermal plasma reactor. The details of this plasma reactor are described elsewhere [Singh et al, 2002]. Following experimental conditions were maintained during preparation of mullite using a thermal plasma reactor:

Sample – 200 g
Arc current - 300 A
Load Voltage - 50 V
Time - 5 minutes

Quality assessment of mullite

Drop test is a popular method used for the evaluation of breakage characteristics, which is carried out under specified conditions. In the present study a series of drop test experiments were designed and carried out for the evaluation of breakage properties of mullite prepared from clay and PAK.

The experimental set up for these breakage studies consist of a cast iron cylindrical shell having a diameter of 12 mm and weighing 2.0 kg. The shell was allowed to fall from a fixed height on the sample, which is placed over cast iron plate. A known quantity (15 g) of –1.2 mm +0.850 mm sample was used in all the experiments. The shell was dropped on the sample for required number of times and the products subjected to sieve analysis. Varying impact energies performed the drop weight tests.

RESULTS AND DISCUSSIONS

Characteristics of feed

PAK used for above studies contains 41.4 % Al_2O_3, 36.7 % SiO_2, 3.4% Fe_2O_3, and 18.8% LOI while clay sample shows 45.6 % Al_2O_3, 38.3 % SiO_2, 2.6% Fe_2O_3 and 13.5% LOI. Morphology and physical characteristics of both the samples are given in Table 1. The mineralogy of PAK and clay samples was found out from their XRD pattern. The PAK comprises of kaolinite and gibbsite (Fig. 1) while in clay sample kaolinite and quartz are present as major phase and goethite, graphite as minor phases (Fig. 2).

Characteristics of Mullite

Mullite prepared from PAK is constituted of 71.8 % Al_2O_3, 28.2 % SiO_2. Mullite from clay has 71.6% Al_2O_3, 28.4 % SiO_2.The mineralogy of mullite phase was also confirmed through XRD. The mullite prepared from PAK (Fig. 3) and clay shows similar (Fig. 4) XRD pattern, through the magnitude of X-ray peaks for latter product is greater.

Table. 1: Morphological and physical characteristics of materials

Details	PAK	Clay	PAK–mullite	Clay-mullite
Morphology	Hard fragments, Friable to semi friable fragments, Brownish red milky white in colour.	Milky white in colour	More or less honey comb structure with dull surface shiny	Smooth surface with glassy shiny
Mineral phase	Kaolinite, gibbsite, quartz, goethite	Kaolinite, quartz, feldspar, goethite	Mullite	Mullite
Physical properties				
Bulk density, g/cc	1.28	1.60	1.3	1.3
True density	2.70	2.65	2.8	2.8
Porosity, %	52.59	39.60	53.57	53.57
d_{80} passing, µm	6094	150	-	-

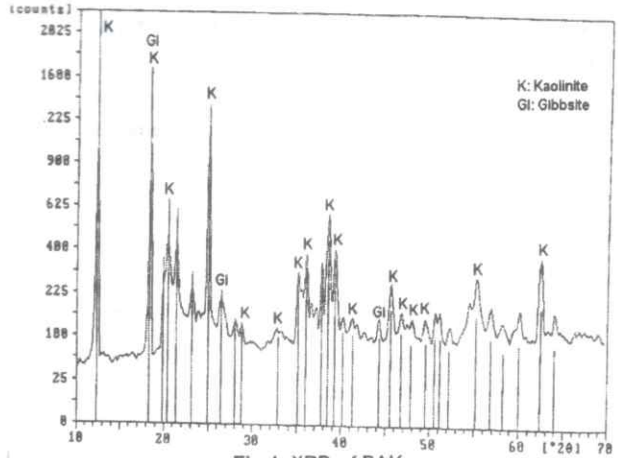

Fig.1. XRD of PAK

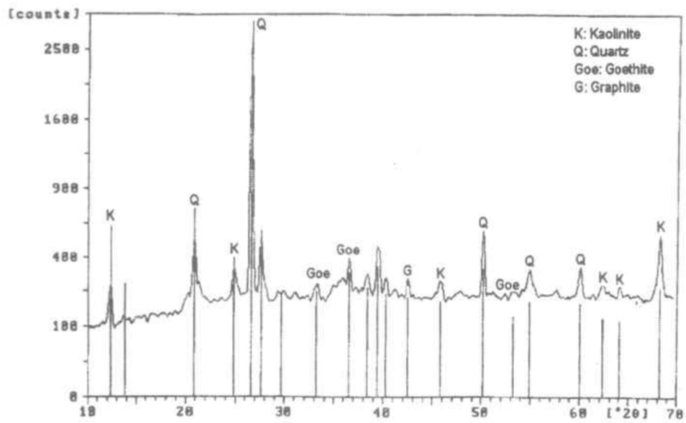

Fig.2. XRD of clay

Quality assessment of mullite

Breakage characteristics of a material to some extent depends on the environment under which the breakage event takes place, based on which breakage occurs through nipping, impact, abrasion, chipping, one-surface loading, double surface loading etc. Bond (1952) proposed an empirical relation, which is still widely used for the prediction of comminution energy in ball and rod mills, even though considerable work on grinding models has been done using discrete element and finite element modeling techniques (Fuerstenau and Han, 2003).

Figures 5 and 6 show the breakage functions measured from clay and PAK-mullites after the drop weight tests. The data are plotted on log-log scale wherein; cumulative weight percent fineness produced is drawn against the dimensionless particle size (Index, n = parent size/progeny size). It can be observed from these figures that the impact energy is largely used for the breakage of particles and greater impact energy increases the product fineness.

The size distribution data collected from the above experiments can be effectively characterized by a parameter t_{10} (Bond, 1952), which are defined as a fraction of the product finer than $1/10^{th}$ of the parent particle size. Similarly, for any other particle size the parameter t_n could be used. Each curve in the above figures has unique t_{10} and t_n values. These t_{10} and. t_n values could be related by means of Fig. 7, which is reported elsewhere (King, 2001; Narayanan and Whiten, 1983; Pauw and Mare, 1988).

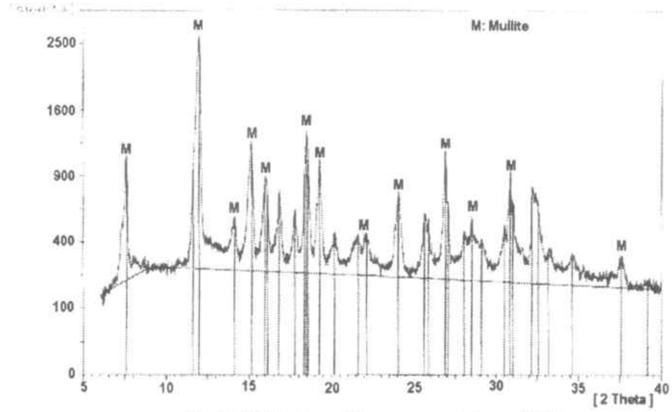

Fig.3. XRD of mullite prepared from PAK

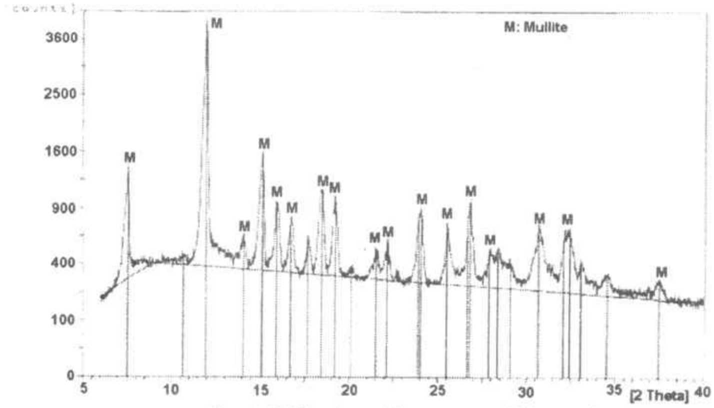

Fig.4. XRD of mullite prepared from clay

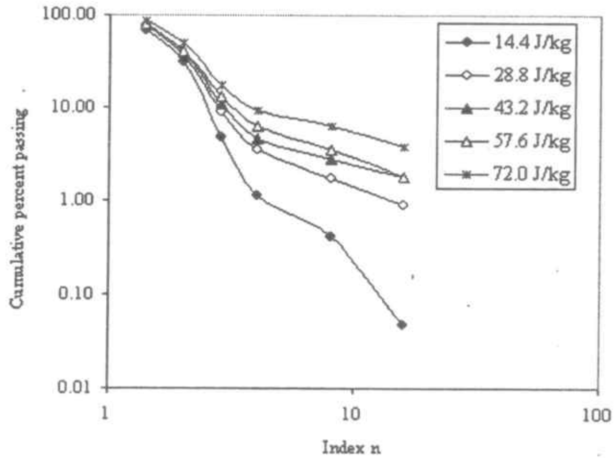

Fig.5: Breakage functions measured from drop weight tests on mullite prepared from clay material

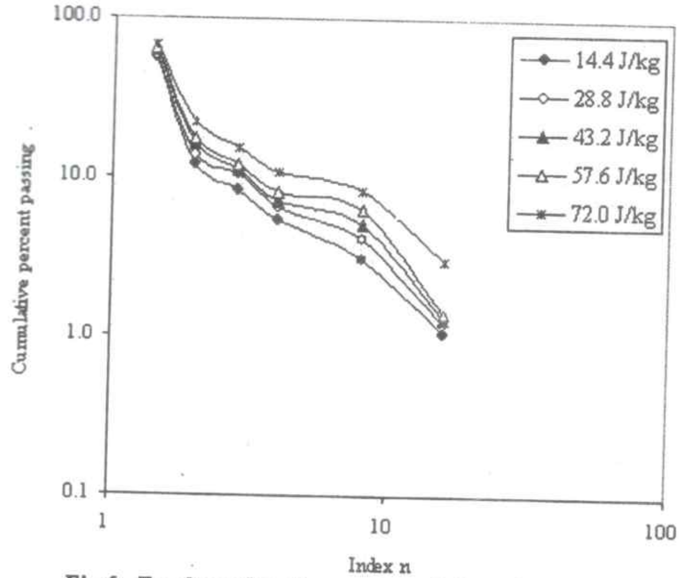

Fig.6: Breakage functions measured from drop weight tests on mullite prepared from PAK

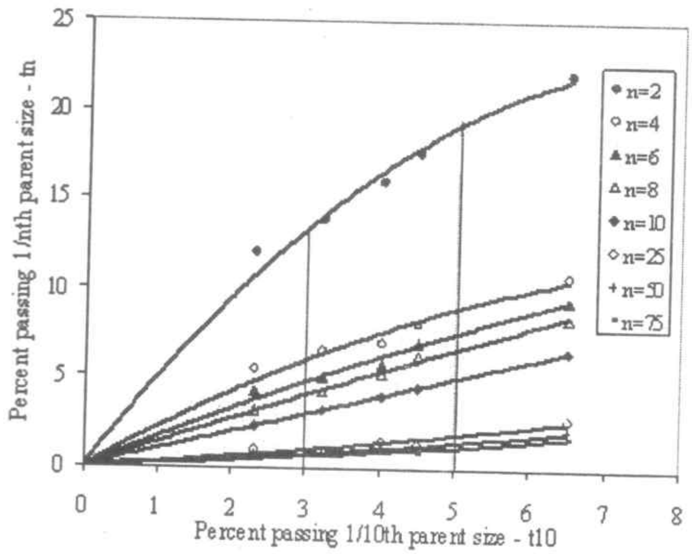

Fig.7: Breakage data presented in terms of the parameter t_{10}. The solid line is a second order polynomial on the data points.

The breakage data on mullite sample prepared from the PAK were used in constructing the Fig. 7. The useful values of *t2*, *t4*, *t25*, *t50* and *t75* are drawn from a specified value of *t10* by referring to this figure and these are presented in Table-2. Similar analysis has been done for the mullite sample prepared from the clay material and results are tabulated in Table-3.

For a specific data of parent particle size 1200 μm and t_{10}=5%, it can be predicted from the table that about 8.9% material is finer than 300μm (t_4 = 8.9%). Similarly particle size finer than 200μm (t_6), 150μm (t_8), 48μm (t_{25}), 24μm (t_{50}), 16μm (t_{75}) are presented. The t_{10} is important parameter for the prediction of breakage characteristics of rock ores. The size distribution of any unknown sample could be predicted if t_{10} parameter is known or calculated using the drop weight tests.

It can be observed from the Tables-2 and 3 that breakage parameter values are varying marginally, which show that the mullites prepared from clay and PAK have more or less similar breakage properties. The energy calculated theoretically as well as empirically and data shown in Table 4. The data indicate that the energy required for breakage is 10.92 J/Kg for mullite prepared from clay and 10.14 J/kg for mullite prepared from PAK. But the theoretical energy for breakage of mullites prepared from clay and PAK is 14.4 J/Kg. The loss in energy occurs due to the sound effect and impact (particle-particle and particle-weight that falls on particle) etc. Thus it is concluded that the mullite obtained by the two different raw materials have shown similar breakage properties.

Table-2: Breakage parameter t_{10} values for mullite sample prepared from the PAK

t_{10}, %	t_4, %	t_6, %	t_8, %	t_{25}, %	t_{50}, %	t_{75}, %
3.0	6.0	4.8	3.8	1.3	1.0	0.8
5.0	8.9	7.6	6.6	2.8	2.2	2.2

Table-3: Breakage parameter t_{10} values for mullite sample prepared from the clay material

t_{10}, %	t_4, %	t_6, %	t_8, %	t_{25}, %	t_{50}, %	t_{75}, %
3.0	6.2	4.3	3.5	1.5	1.3	1.0
5.0	8.9	7.3	6	3.0	2.4	2.1

Table.4. Typical energy calculation results for both clay and PAK

Drop 1	Mullite prepared from Clay	Mullite prepared from PAK
E, J/Kg	14.4	14.4
F_{80}	1000	1050
P_{80}	980	1030
W, J/Kg	10.92	10.14

CONCLUSIONS

The following conclusions may be drawn from the mullites prepared from two different raw materials.

- Thermal plasma can be successfully used to prepare mullites from PAK and clay. Mullite from PAK by this technique is reported first time.
- Due to very high temperature and rapid heat transfer associated with thermal plasma the formation of mullite is possible in a very short time period of five minutes by thermal plasma processing.
- In clay, d_{80} passing size is 0.15 mm with 45.6 Al_2O_3 and 38.3% SiO_2,

whereas d_{80} passing size for PAK is 6.1 mm with 41.4 Al_2O_3, and 36.7% SiO_2.

- The breakage parameter values determined for mullites from both clay and PAK shown same breakage properties in spite of both the materials possess different physical and chemical properties.

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SIGNATURES OF GLACIO-EUSTASY DUE TO LAST GLACIAL CYCLE IN THE SHELF SEDIMENTS OFF KASARGOD-MANGALORE COAST

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ABSTRACT

The Last Glacial Cycle has left impressions on the continental shelf and along the onshore rocky promontories of west coast of India. Bathymetric and shallow seismic surveys along two shore orthogonal transects, across almost the entire width of the continental shelf off Kasargod-Mangalore coast, on board GSI's coastal research vessel Samudra Shaudhikama during the cruise ST 188, have picked up three calcareous to sandy ridges almost parallel to the present shoreline at 122m, 86m and 61m water depths. The ridges are composed of high energy coarse calcareous sand. The surface sediments in the intervening swales are silty clay to clayey silt and sometimes sand-silt-clay which are associated with low energy depositional environment. The fine silty clay in the swales grades into sandy material near the ridges. The presence of coarse sand and buried coral colonies, shell fragments point to a high energy environment and their formation can be attributed to palaeoshoreline during the low sea level stands.

The sequence of events during the Last Glacial Cycle for the Kerala coast begins with the lowering of sea level which was set into motion roughly 35 ka BP with the initiation of the glaciation. During the peak of the glaciation the sea level was lowered to 122m. The peak of the glaciation occurred around 18 ka. Subsequently warming gave rise to melting of the polar ice caps and resulted in the rise of sea level. The rise of the sea level was interrupted at times due to cold phases, giving rise to low stands around mesoglaciation and later little ice ages caused stand stills during Late Holocene.

Introduction

The first scientific observation, for the purpose of measuring sea-level changes, were made in the 18th century after the establishment of the first tide-gauge datum in 1682 at Amsterdam by a physicist Hayrne. Later in 1702 he engraved some marks on the rocks in Sweden and Zendini used steps of the Doge's Palace as sea level datum in Venice in 1732. Studies of Late Pleistocene-Holocene changes have improved substantially during the last few decades due to development in dating techniques, satellite sensing data and IGCP activities beginning with IGCP 61, IGCP 200, and so on till IGCP 464. The Quaternary climatic history has been subdivided on the basis of the drift deposits and the four major glaciations have been named in the ascending order as Gunz, Mindel, Riss and Wurm with intervening warmer periods. The most important phenomenon related to these climatic variations, observable all over the globe, was that of the world wide glacio-eustatic sea level changes. A close relationship however, existed between climatic stages and the eustatic sea levels, glacials lowered the sea levels while interglacials were periods of high sea levels.

An attempt has been made in this study to collect evidences of low and high sea level stands related to the Last Glacial Cycle, off Kasargod coast of Kerala, India. The signatures of regression, transgression and

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still stands are retained in the continental shelf with or without geomorphic expressions in the sedimentologic, palaeontologic and chemical character of the seabed sediments. These impressions are better preserved in the continental shelves farthest from the deltaic regions.

Fairbridge, R.W.(1961), Fairbanks, R.G. (1989), Pirazzoli, P.A. (1989), Shackleton, N.J. (1987), Shepard, F.P.(1963), Milliman, J.D. and Emery, K.O. (1968) are some researchers who will be always remembered for their contribution to the studies on sea level changes Events of late Quaternary sea level changes are known from both west and east coasts of India. Indications of low sea level stands from some offshore geomorphic features were brought to light by the geoscientists (Banerjee, A and Sengupta, R.1990) of GSI Marine Wing during the cruises on board GSI Research Vessel Kaustubh.

Methodology

Bathymetric and shallow seismic surveys, along two shore orthogonal transects KG3 and KG4, almost 50 km apart, across the entire width of the continental shelf off Kasaragod and Mangalore coast. Vibro-core, gravity core and grab samples were collected from selected areas of transects based on bathymetric and seismic records. Samples were analysed in the laboratory for grain-size, sedimentology, palaeontology, carbonates and inferences made against the perspective of palaeogeographic features of these sediments, were deposited in. Field work was carried out onshore and signatures of high sea stands were collected.

Shelf Morphology

The late Quaternary glacials and interglacials in the tropical areas are manifested as arid-cold or warm-humid climates and are recorded in the shelf sediments as signatures of regression and transgression respectively. Last Glacial Cycle has left various types of impressions on the continental shelf and along the onshore rocky promontories of Kerala coast. The bathymetric and seismic records have revealed evidences of low and high sea level stands related mostly to regressions and transgressions of late Quaternary.

Bathymetric and shallow seismic surveys carried out, along two shore orthogonal transects KG3 (67 km) and KG4 (65 km), across the entire width of the continental shelf off Kasargod (Fig 1), on board GSI's coastal research vessel Samudra Shaudhikama (cruise ST-188) have picked up three calcareous to sandy ridges 1, 2 and 3 almost parallel to the present shoreline at 122m (Fig 2), 86m and 61m water depths respectively. The image of ridge 1 along with the sea floor at 122m depth has been recorded by Side Scan Sonar (Fig 3). The shelf is gently sloping towards west and is rather smooth (Fig.1). The gradient of the shelf is 1:554 in the inner shelf and the almost flat sea floor is interrupted by shore parallel ridges at 61m, 86m, and 122m depth. The width of the shelf is about 75 km in this sector and the shelf break occurs at 180m depth. The ridges 1 and 2 are made up of coralline debris (with *Acropora* and *Porites*) composed of coarse silica sand, bioclasts of small bivalves and grainstones often cemented together with calcareous matrix. The ridge is prominent in its uniform morphology and consistency in its crest relief, in both transects. The flanks of these, ridges are partially buried under sediments forming onlap structures. The swales are composed of fine silty sand to silty clay, fining towards shelf break. Biogenic remains from these ridges have been sent for dating by radiocarbon. The sediment on this ridge is seen to contain 52.36% to 77.8% of +230 fraction. Width of the exposed part of the ridge 1 is 357m off Kasargod in the transect KG1. The presence of coarse sand and dead coral reef, shell fragments point to a high energy environment and their formation can be explained due to lowered sea level. The three ridges picked up in the seismic as well as bathymetric records vary in relief from 3 to 6m in general, at places it is 15m even. The flanks are steeper on the seaward side. The ridges in the outer shelf are rich in carbonate material whereas those in the inner shelf zone are rich in silicate sands.

Surface sediment distribution in the shelf from Kasargod to Mangalore shows coarse to medium sand in the seabed sediment up to a depth of nearly 30m isobath. From 30m isobath to 61m the sediment is silty sand in the shallow area to clayey sand in the deeper region in the eastern part of the area. Silty clay to clayey sand is seen on the western part. The surface sediments in the intervening swales are silty clay to clayey silt and sometimes sand silt clay which are associated with low energy depositional environment. From 61m to about 86m depth the sediment is sand-silt-clay mixed with calcareous sand near the ridge. Based on data of subbottom profiling and selective sampling, a reef like linear feature has been traced around 86 m depth for a distance of about 15 km. Presence of seaweeds, coral debris in a linear zone is indicative of a possible coral reef. Silica sands at a location on the ridge 1, include rounded to subrounded grains of quartz, plagioclase, subangular garnet and subrounded ilmenite

The swales are composed of silty fine sand to silty clay, fining progressively towards shelf break. Biogenic remains from these ridges have been dated by radiocarbon. The presence of coarse sand and buried coral colonies, shell fragments point to a high energy environment and their formation can be attributed to palaeo-shoreline formed during the low sea level stands in a transgressive phase. Drop in terrigenous input during the LGM is indicated in the chemistry of sediments near ridge 1. Phosphatic concretions, smooth, rounded, dark grey, measuring 0.5mm to 2mm are seen in the sediment at 86m ridge.

In the inner shelf region at about 105cm subsurface carbonaceous clay, carbonized wood and peat has been detected in the core samples. There is a consistency in the occurrence of the peat and dark carbonaceous clay. In the north off Karwar, during another cruise of GSI research vessel Samudra Shaudhikama, similar woody material from inner shelf subsurface, were dated by Nambiar et al (1991) and the radiocarbon ages were 9630±120 y BP and 8620±300 y BP. Pollen analysis of core samples from Arabian Sea indicated a humid climate with rich mangrove vegetation in the west coast around this time. Relicts of mangrove vegetation exists even today along the west coast. The transgression of the sea might have resulted in destruction of the coastal vegetation giving rise to carbonized wood and peat beds (Nambiar,1991). This is in agreement with the observation of Geeta et al (1997) of a moist phase around 9 ka BP. The age data indicates that this transgression took place between 8ka and 9ka BP.

Geochronology

The continental shelf along the west coast of India is characterized by a series of regressive and transgressive sequences which carry the signals of climatic changes and sea level oscillations. The age for the ridge 1 at 122m depth corresponds to the beginning of deglaciation leading to transgression, as has been recorded along the east coast of India (Faruque and Lahiri, 2002). Followed by deposition in a low energy environment along the swales between ridges 1 and 2. Due to a moderate cooling phase -- referred as Cochrane-Bothnian cool phase (Fairbridge, 1961) – at 8ka to 9ka BP, sea level rise was arrested, at 45-60m below the present sea level, similar to the sequence of events in the east coast (Faruque and Lahiri, 2002). The rate of sea level rise from ridge 1 to Ridge 2 works out at 12mm / yr and from ridge 2 (Cochrane-Bothnian cool phase) till the time it reached the present sea level ca 6ka B.P. (Fairbridge 1961), the rate of sea level rise was faster at 21.4mm / yr. Subsequently, there was warming, deglaciation and transgression continued. Vaz (2008) has recorded beach rocks dated 6110 years BP at 2m above pmsl. from Mandapam, Rameswaram.

Onshore features

Geological traverses along the coastal tracts from Karwar in the north to Tellicherry and Mahe and again from Cochin to Kanyakumari were taken to identify signatures of marine incursion. Wave cut notches were located at 2.7m above pmsl on the rocky promontories near Edavai and at Tellicherry (Fig 4 and 5). Shell beds and beach rocks at 2m above the pmsl were seen hear Kovakulam and beach rocks have been recorded at 2m above pmsl at Vattakottai. However, precise dating of wave cut notches have not been possible. So to fix the time for rise of sea level to 2.7m above present sea level will be hypothetical.

Conclusion

The rhythm of climatic change was much more complex than the simple idea of climatic alternation, and studies during the last few decades have revealed that every glacial period was interrupted by minor interglacial phases, during which the ice front receded, and similarly each interglacial stage was punctuated by colder phases during which ice sheets formed afresh or made notable advance in their shrunken conditions. The glacials in the tropics, away from the polar areas, did not have actual glacial ice, but the glacials and the interglacials were adequately reflected in the comparable climatic conditions. The Late Quaternary glacials and interglacials in the tropical areas are manifested as arid-cold or warm-humid climates and are recorded in the shelf sediments as signatures of regression and transgression respectively. Last Glacial cycle has left various types of impressions on the continetal shelf and along the onshore rocky promontories of North Kerala coast.

The signatures of low sea level stands in the continental shelf off Kerala coast along with the wave cut notches and impressions of high sea stands, sediment character in the shelf, biota along the ridges and origin of the authigenic minerals put together provide data on the sequence of geological processes those were initiated due to Last Glacial Cycle (LGC) and continued to influence the glacio-eustatic oscillation. Except that not much evidence could be picked up on the regressive phase which might have begun at the initial stage of cooling due to LGC. The Riss/Wurm interglacial might have seen the sea level at slightly higher than the present level (Fairbridge 1961). As studied by earlier workers (Fairbridge 1989, Pirazzoli 1987, Fairbanks, 1989) from the other shores of the world Last Glacial Cycle led to lowering of the sea level which began about 35 ka B.P. It reached -122m below the present level about 18k years B.P. in Indian context as seen on the east coast (Faruque and Lahiri, 2002). Late Pleistocene formation was exposed to sub-aerial condition and erosion. It continued to remain so for a couple of thousand years and by about 14 ka B.P. global warming sets in and the melting of polar ice leads to rise of sea level. The rise of sea level was rather slow and by the time the sea level had reached -74m depth a short phase glaciation arrested the rise of sea level. This glacial stage has been identified as mesoglaciation by Fairbridge (1961).A hot and humid phase followed the Cochrane-Bothnian cool phase and the transgression inundated rich mangrove vegetation along the Kerala coast. Rivers debouched directly into the continental slope and abyssal plain (Faruque and Lahiri, 2002). By about Late Holocene, the final shape of the seabed morphology was laid with minor changes due to near shore high-energy morphodynamics. Rise of sea level to +2m to +5m above the present sea level has been noted from various parts of Indian coast. The radiocarbon ages of *Acropora* and *Arca* from Mandapam beach rock, it is evident that sea level was at 2m amsl between 5660 and 6110 years BP.

(Vaz et al, 2008). As for the present trend the sea level along Kerala coast is ascending due to the interglacial compounded by global warming.

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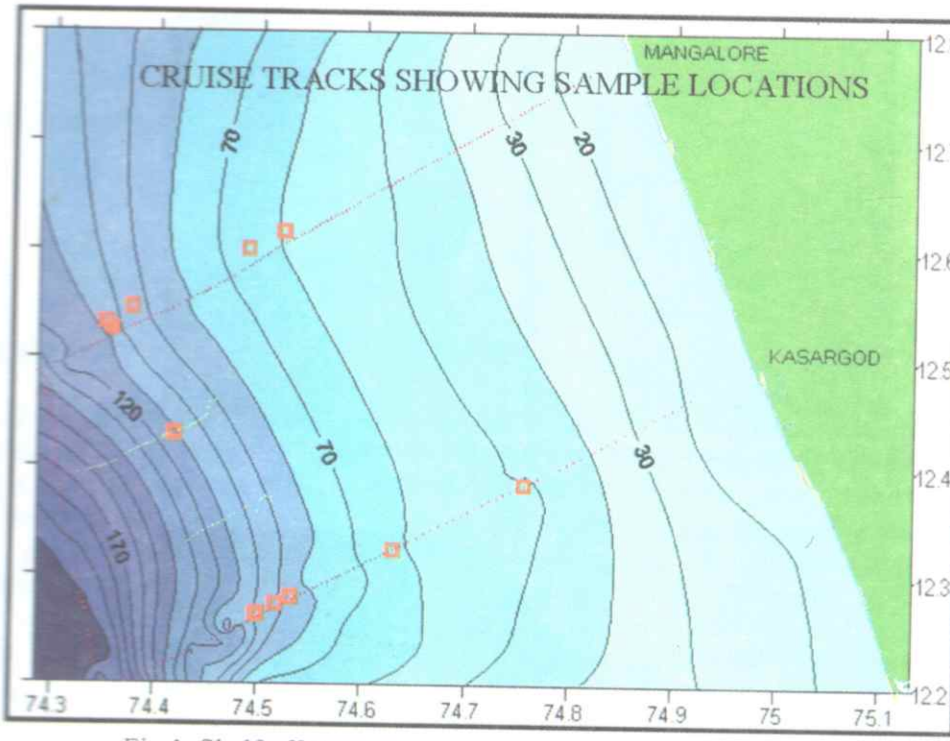

Fig.1 Shelf off Kasargod under study with the cruise tracks.

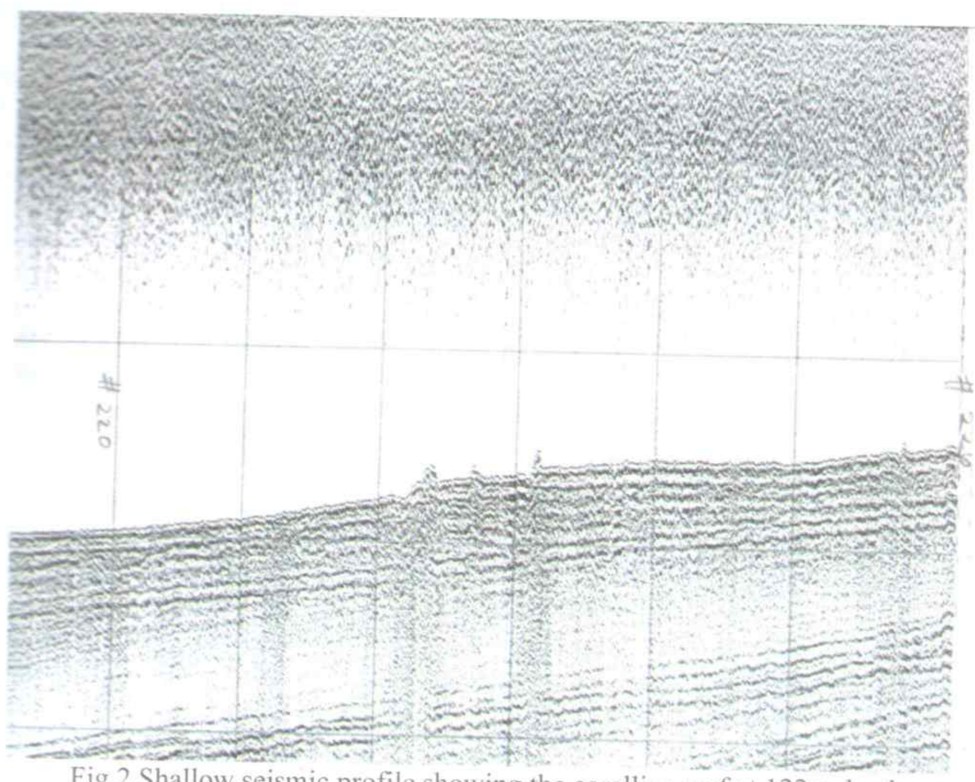
Fig.2 Shallow seismic profile showing the coralline reef at 122m depth in the shelf off Kasargod.

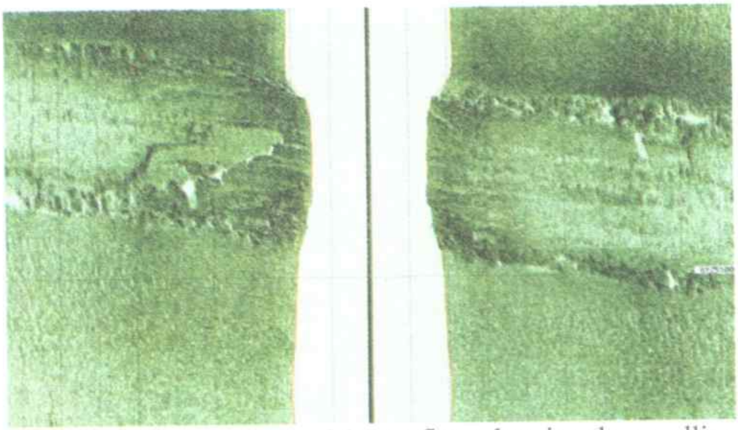

Fig 3. Side Scan Sonar image of the seafloor showing the coralline reef at 122m depth off Kasargod.

Fig 4, Wave cut notch on rocky promontory due to high sea level at Edavai.

Fig.5 Wave cut notch above the present sea level at Tellicherry, Kerala

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ENVIRONMENTAL IMPACTS OF MINING INDUSTRIES WITH SPECIAL REFERENCE TO ORISSA

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INTRODUCTION

The nature of the earth around us has a profound influence on our environment because it not only supplies the primary minerals in form of earth resources, its fundamental geomorphic features like, mountains, plains, valleys, shorelines etc. influence on characteristics, density and style of life. A French Geologist of 19th century once claimed that "the rock types even have effect on health and intellectual development of the people of a region and at least on national economy". Ultramafic rocks with low halogens (Iodine) can produce deficiency of the element in pituitary gland (infrathyroid) which controls intelligence, as much as excess Fluoride in granites causes fluorosis. Different rock types operate through different characteristics – chemical and mineralogical compositions, compactness, conductivity, reaction to water etc. Springs, fertility, vegetation, ground water, settlement, population distribution and configuration and architectural style of dwelling, even hunting and fishing are rock dependant, The finer sculptures of Greeks developed on availability of marble, Konarak and Khajuraho for khandalite and Vindhyan limestones respectively, and similarly, but for the soft nummulitic limestone, the gigantic pyramids of Egypt could not have been conceived. Clays, Tertiary limestone, alabaster, soapstone, volcanic tuffs and pumice have their effect on development of art habits. The rich ancient architecture and metallic artifacts of India are but records in stone that man has been mining earth resources for development of civilization as well as for expression of his finer quality. In contrast the modern energy resources – coal and oil, have brought an explosive civilization and global environmental degradation.

It is now proven beyond doubt that, rock types of a region have a profound influence on health and habitats. **Agriculture is nothing but mining trace elements from soil**. Earth borne metabolic diseases such as fluorosis, goiter, manganosis, plumbism, silicosis, heavy metal pollution, even global warming are due to mining and mineral based industries. So also depletion of water table, desertification and soil Stalinization and degradation are due to excessive "mining" of ground water.

Mineral sector and mining industry is the key drive of a country's industrial growth. However, myopic vision, disregard to natural laws and processes and economic bias, in the wake of its execution, has brought about severe environmental repercussion and social unrest. The greatest challenge is how to make the mining industry environmentally friendly, socially acceptable and sustainable.

It is true that mining can not be truly sustainable and environmentally friendly because ore bodies are finite elements and nonreplenishable. The very process of mining exhausts the stock. Even the best managed mine leaves an environmental footprint, destabilize natural elements of mineral assemblages, changes the natural environment and attempts to mould into an anthropogenic frame work. But minerals are necessary and required by the society. The issue is not whether mining should be undertaken or not, but how to make it environmentally friendly, socially acceptable and sustainable in time and space. A new technology and ethic is needed to make mining socially acceptable and not just economically viable.

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A stark observation that has come to the notice that "**while the natives living over mineral rich belts world over, reels below poverty line, for those consuming excessive earth resources elsewhere, the quality of life is not desirable**".

Although it is difficult to reverse the trend of development of a technoholic society based on earth resources utilization, even slowing down is considered stupid, "for the first time on man's life on earth, he is being asked to reform his economic and technological advancement exclusively based on inorganic mineral resources or at least direct it differently from before and concentrate on the organic growth of a holistic environmental system."

One of the modern approaches to make mining reasonably to appear environmentally acceptable is the method of Environmental Impact Analysis and an Environmental Management Plan for a project or group of projects. Where as, it attempts to recognize the negative impacts of an activity and proposes remedies to contain the adverse impacts, it rarely takes into account the chain reaction that the activity generates downstream space and time. Industrialization, based on the minerals brought out of the ground and consequent network of transportation and settlements have both local and regional impacts, which are rarely taken into account when environmental clearance of a mining project is sought. For example, coal mining and establishment of thermal power plants from the mined coal. It also gives low value and less importance to other resources like, soil, water and plants and habitats including the natives, which have maintained a time tested sustainable environment over the same land. Biodiversity of an ecosystem once lost by mining and mineral industry can not be replaced by any means. Even extensive plantation does not replace a forest ecosystem. The expanding soap bubble of environmental stress in such regions grows from the mines and mineral industry but is rarely realized until it exceeds stress limit and appears in social unrest. A vision for mining with a human face is more than necessary for a mineral rich State like Orissa.

Read, Heard, Saw And So ?

Read: The erstwhile USBM, now merged in USGS ,once commanded its Geologists: *Thou shall not pollute the air nor contaminate the water or tear apart the land but supply mineral matter to the Society.* (T.P.Flawn in Environmental Geology).

Heard: A doyen of Indian Geology, while speaking on gold prospecting remarked: The Earth is *Ratnagarva Vasundhara* (bejeweled). The duty of the Geologist is to bring it out the *Ratna*. (B.P.Radhakrishnan while speaking at IIT-Bombay).

Saw: A renowned Mining Engineer while decorated with compliments in an Environment Seminar replied that he was responsible for large pits and dumps on earth surface and does not deserve the laurel. (A.N.Banerjee speaking in School of Mines, Dhanbad).

And So: When will the *Ratnakar Dashyu* will receive admonishment from his wife that she is not a partner of sins and commissions of his profession of robbery and then wake up to change himself to *Valmiki* ? (K.C.Sahu).

NATURAL ENVIRONMENTAL RESOURCES OF ORISSA

The natural geomorphic resources of Orissa comprises of:

1. A 480 km. long shore line along the Bay of Bengal, dotted with fishing community, long stretches scenic golden sand beach, a large brackish water lagoon –Chilika, famous for aquaculture, and a number of estuaries, rich in rare species of turtle, alligator and dolphin.

2. Westward, parallel to the coast line, is a stretch of fertile deltaic plains, about 60 km.wide.
3. A central axial high land flanked on either sides by intermediate uplands of peneplains and dissected mountains. **This zone is rich in minerals and forest resources and is considered to be a museum of biospheric reserve of the State.**
4. A set of easterly flowing rivers, the major ones being the Mahanadi, Brahmani Baitarani, Balanga, Subernarekha and Rushikulya, all flow across the highland and drain into Bay of Bengal.

The geological resources, which sensitize environment in Orissa, comprise of:

*** Extensive occurrences of sedimentary iron ores in the Precambrian Iron Ore Formation in central and northern region of the State along the famous Horse Shoe Synclinorium of Keonjhar, Sundergarh and Mayurbhanj district and in a few isolated patches at Daitari and Badampahar. The ore is bedded and banded, occupies hill-tops and often becomes soft and powdery at depth. Manganese ores associated with iron ores occur at geomorphically lower altitude, where as those in Khandalite of south Orissa are phosphorous rich. There is a stampede to establish iron and steel industries in the region, which already has mega steel plants at Rourkela, Tatanagar and mini steel plant at Barbil. A large number of mines operate, also to export rich iron ores into global market through Paradip port.

*** Ninety percent of India's chromite ore resources are located in the ultramafic rocks of Sukinda and Baula regions. The former is extensively altered and lateritised on top. The altered over burden has been found to be nickel rich and is poised to be a source of nickel, However, geochemical alteration appears to have generated some amount of hexavalent chromium by oxidation of the trivalent chromium of the chromite and is a matter of great concern to the mining industry.

*** The high level peneplained plateau surfaces over khandalite terrain in SW region of Orissa and isolated patches of aluminous shales and metavolcanics, carry massive bauxite deposits of metallurgical grade. With cheap power sources from adjacent hydel projects and coal based power plants, aluminum industries, from mining, smelting to refining, are on way of rapid establishment.

*** Gondowana rocks, which carry the coal deposits, occupy all along the Mahanadi – Brahmani valleys, extend from Korba of Chhatisgarh to Ib valley and Talchir field in Orissa. The easily weatherable shales and sandstones develop fertile plain lands with thick soil cover and support both agricultural and forest growth.

Structural and lithological elements of Gondowana have strong control over the courses of Mahanadi and Brahmani rivers. The intensity of sediment transport through these rivers is closely related to the erosional flux developed in the coal fields in the respective watersheds.

Sixty two million tonnes of coal resources are known to occur in the two coal fields of Orissa, more than 60% of which is used for power generation, With 35 to 40 % ash in the power plant coal, the ash generated in the power plants penultimately adds to the erosional and mine fluxes to flow down to coastal plains through these rivers.

Availability of coal has also encouraged establishment of iron and steel, ferroalloys and aluminum industries.

*** Other minerals which could significant environmental problems in their exploitation are the limestone and dolomite deposits in Sundergarh, Bargarh and Koraput districts and mining of beach sand for monazite at Gopalpur.

ENVIRONMENTAL IMPACT IN EXPLOITATION OF MINERALS IN ORISSA

Impacts beyond comprehension

The crust of the earth has 8 % Ferrous Iron which is being continuously oxidised by our oxidising atmosphere producing red soil(laterite). Mining expedites the process by uncovering underneath materials.Oxidation of each atom of Ferrous Iron to Ferric state takes one atom of oxygen from atmosphere. Only 300ft. of crust if oxidised will strip out all the oxygen of the atmosphere. Therefore, whenever we dig (for mining or otherwise), we dig for our grave.

Geological formation of coal could be made possible when plants inhaled CO2 from ancient atmosphere, fixed the Carbon in wood tissue, returned the Oxygen and finally on death got buried in sediment.The process led to evolution of modern atmosphere of 21 % Oxygen. If the same buried Carbon(coal) is mined out and burnt, it would take back the same amount of Oxygen accumulated in the atmosphere. Only a *novoKalidas* can attempt to burn out the accumulated Oxygen stuff by fossil fuel burning. (carbon emission to atmosphere is another aspect).

Exploitation is meant here, for mining and transportation of mineral products, value addition techniques and utilization for production of intermediate, semi finished and finished products in a plant or factory. Of the total land area of 155,707 sq.km. of the State, mining lease for various minerals has been granted for 998.26 sq.km. – only 0.64% of the land, The operative mines spread over 725 sq.km. with surface right for 500 sq.km. (0.3%). Actually 0.1 % of the State's land area is actively mined and therefore at once, appears to be too negligible a site to have a significant effect on the environment of the State, except at local levels. However, the downstream chain reaction of the mining process has significant impact on the entire State. Deforestation, loss of top soil, siltation of drainage channels, coastal floods, raising of ambient temperature and consequent dehydration of soil, loss of agricultural land, air, water and soil pollution, appropriation of resources, displacement of natives and social unrest are all results of the mining activity. Besides, sprouting of mineral based industries like, steel & alloys, smelters and refineries, power plants, ports and harbors and network of transportation bring in their associated environmental problems and issues. All these, however, are compensated by regional development and economic progress of the State and individuals.

Iron Ores: Geologically, all the iron ore resources of the State occur on hill tops. Overburden stripping and mining changes the erstwhile topography with consequent changes of drainage pattern of the region. The ore is fragile and powdery at depth and washout of the fines and overburden materials silts up and pollutes streams and river channels downstream and despoil agricultural lands. If marginally sub grade ores are to be upgraded by crushing, jigging and washing or the fines palletized to broaden the resources base, the size of the dumps may decrease, but water pollution and siltation downstream would automatically increase. Large number of iron and steel smelters that have sprouted near or along the iron ore belt, besides polluting air, produce slag dumps.Leachate from dumps is obviously highly polluting to local water bodies. Transportation of mined materials from mines to smelters or port has brought several environmental problems and discomfort to residents around the mines and along the route.

Chrome Ores: Besides large scale stripping of forest land and generation of mountains of overburden materials, chromite mining has created large pits and excavations. Huge piles of overburden soil, rich in nickel, await utilization. Concern for hexavalent chromium contamination arising out of mining has led to establishment of effluent treatment plants by mining companies. Even if Cr (vi) is generated in the fragile ore zone and trickles out into the quarry water or adjacent stream, the element is likely to be absorbed by the goethite matrices of the pervading laterite (Goethite acts as a sponge to Cr and Ni cations) or is reduced back to Cr (iii) state when it comes in contact with humic substances (reducing environment) so common along the water channel (say Damsala Nala) flowing through forest. Some Scientists have reported dechromification along effluent discharge channels of a chrome chemical factory at north Bombay, when the open duct passes through cattle sheds of slums. The detection of hexavalent chromium in certain water pools in mines and streams, therefore is likely to be anomalous and of local significance. Hexavalent chromium downstream section of Damsala Nala and Brahmani River is low. The treatment of mine water effluent, although aims to remove the Cr (vi) by addition of chemicals, will further pollute the water when the natural set up of the region is capable of absorbing the deleterious metal from the effluent. For a non-point source of pollution (such as mine belt), water treatment and purification is an impracticable proposition. Ferrochrome and chrome chemical factories, however, are likely to generate hexavalent chromium and pollute surface and ground water, and therefore need precautionary measures.

A natural and sustainable method of combating possible Cr(vi) pollution in Sukinda region is to create anoxic environment in the ground surrounding the mining areas and dumps by developing organic trades and habits, such as, diaries, hatcheries, piggeries and horticultural practices including afforestation and plantation activities. The anoxic ground environment produced by these activities would automatically reduce Cr (vi) to Cr (iii), immobilize the element and prevent water pollution, if and when Cr (vi) is released from the mining activities.

Winning of nickel from the stocked overburden soil will involve large scale mechanical and chemical processes including setting up of smelter and electro refining devices, whereby the region will be extremely vulnerable to nickel contamination and for which suitable measures must be built in. Nickel is known to be a strongly carcinogenic element.

Bauxite: The most visible adverse impact of bauxite mining is destruction of surface vegetation, top soil, and ancient stable slopes, damage to streams and water channels and associated evils of open cast mining. Smelting and refining usher problems like waste disposal such as Red mud and fluoride fallouts. Since, most bauxite deposits are in forest land and tribal regions, ecological and social issues have strong implication in mining of bauxite in Orissa.

Coal: Open cast mining of coal, though simpler, has the most adverse effect on environment. Besides land despoiling, large excavations and change of local hydrological characters, air, water and sound pollution are conspicuous in coal mining. The ambient temperature increase is added spontaneous combustion, oxidation and mine fires. Washing and cleaning of coal generates large tailings, which add up to the overburden dumps. Progressive land filling and reclamation of slopes followed by afforestation as mining progresses can partly cure the environmental damage. Thermal power plants, set up at pit heads add to the increased ambient temperature. Fly ash, generated in such plants, accumulates in ponds and mounds and damages the water regime around. Utilization of fly ash for various purposes is called for, more so in stowing of stope areas in the coal mine. Switching over to relatively cleaner technology of coal combustion such as, from conventional coal firing to fluidize bed technique, hydraulic material transport of feed or fired products, efficient precipitators and scrubbers in power plants, modern ash management techniques and regulatory enforcement of fly ash use, would greatly decrease environmental stress around thermal plants.

Coal mining alone mobilizes and brings to the surface more than 200,000 tonnes of Uranium, the fate of which in biosphere is little understood. (W.S.Fyfe)

New discovery, opening of mines and expansion of production of coal in IB valley coal field and setting up of power plants in the region, contributes large volume of silt and sediment into the Hirakud reservoir, The latest stampede of mini steel plants in the region adds to the process, As such, similar expansion in Korba coal field equally contributes silt to the Mahanadi river upstream the dam. Besides decreasing the life of the dam and the water holding capacity of the reservoir which also protects coastal flooding during heavy rains in Orissa, the lateral pressure of the silt and mud could vitiate the safety of the dam and consequently the towns and cities downstream.

Others: Other mining activities that can be considered to bring in regional environmental problems in the State are, limestone and dolomite quarries and associated cement industries. The placer mining in Gopalpur operates in an ecologically fragile CRZ and though boasts for environmentally friendly "Plough back residue" technique, it is likely to mobilize finer particles and increase the turbidity of the coastal water and adversely effect fishing industry. With the well known long shore current prevalent along the east coast, rapid siltation of Chilika mouth and Paradip port is not ruled out.

Throughout history, tribes and nations have been fighting against each other with arms and ammunition. Modern man fights against earth with chain-saw, bulldozer, shovel, explosives and excavators.

Many environmental damages mentioned above, arising out of mineral exploitation can be healed by application of standard curative measures in mining and mineral industries. These are: land filling and reclamation after excavation followed by compensatory reforestation, noise and dust suppression, concealed transportation networks of raw materials etc. Similarly, provision of precipitators, scrubbers, effluent treatment plants and waste management practices such as, lining of fly ash and red-mud ponds including utilization of wastes for new products, would prevent adverse impacts on environment, However, higher order impacts of mining industries can not be contained and a price has to be paid for extraction of earth resources. For examples:

- The ambient temperature of Orissa especially that of the coal belt and regions with intensive mining activities and mineral industries have risen up significantly. It has several meteoro-hydrological repercussions arising out of annual precipitations and coastal storms and cyclones.
- Coastal flooding, in spite of decreasing rain fall, are on rise because of increased erosional flux from the hinterland consequent to deforestation, land stripping, washouts from mine overburdens, ash and slag dumps. A simple mineralogical study of the sediments at the depositional sites shows the provenance. Increase of bed level of Brahmani and Kathjori and northward shift of Mahanadi bank near Cuttack during last few decades, can not be missed by any vigilant land planner.

- Chronic water shortage due to its diversion to the industries, local and regional water table depletion and recurrent droughts in erstwhile forest region and water pollution with heavy metals and chemicals are common. Respiratory diseases in mining areas and power plants are on increase.
- Social conflicts and unrests have increased in mining and industrial belts and have fuelled political opportunism and mafia activities. Apparently such conflicts are not just confined PAPs (Project Affected People) and Project Implementers, it has spilled over to man and animals when the forest and lands on which they lived is cleared out for mining and settlement and the few streaks of streams and rivulet on which they survive dries up. The tigers yield to poachers, the deers end up on the diner tables and the elephants descend down to villages and urban suburbs for rampage.

Environmental degradation arising out of mining industry ends up with loss of biodiversity and destruction of ecosystem services. Ecosystem services are Nature's nurture and important for those species which are more complex and higher up in hierarchy, for example, humans. The "Eco-servers" supply fresh water, filter pollutants in stream, provide breeding ground for fish, control erosion, buffer human community from storms and Tsunamis, harbor insects that pollinate crops or attack crop pests, absorb CO2 from atmosphere and finally provide food, medicine, shelter and fuel, particularly for poorer section of the society. The moment the natural world is destroyed by modern activities like mining and industries, the responsibility to sustain the human society falls on the ingenuity to find substitute servers. Experience shows that the substitutes are strong eco-disruptor, worse than the cause. For examples, tractor is a poor substitute for plow because, the former requires fuel oil and cause pollution but the later gives dung. To deliver a half liter bottle of drinking water to costumer, at least 10 liters of natural water is degraded by way of collection, processing, bottling, transport and distribution. .Besides, "diversity bequeaths resilience and we need all the resilience we can muster to deal with the global changes descending upon us. Who knows what catastrophic disease lies in wait in our future. Clear the forest, and mining industry does, it is like emptying our tool kit of natural medicine". That is why the sixth extinction is considered to be already here, this time ushered not by Nature but by Man.

WHAT IS THE SOLUTION?

Minerals are needed for progress and mining industry has come to stay. But conflicts in mining arise due to,

- When it attempts to replace a time tested, land based sustainable economy or ecology by an explosive "time limited" economy (till the mineral reserve lasts).
- When it appropriates resources, that is, "robs Peter (the natives) and pays Paul (the New comers) and exports out the benefits of the pumped out earth resources from the ground and bestows petty compensations or "Bread and Circus" to the natives.
- Worst of all, for example, when limestones stripped out of regions with rich habitats, is converted to cement for developing a concrete jungle like that of Noida near Delhi and auto-jammed concrete road of Mumbai, where the quality of life is least desirable, the very purpose of mining stated right at the beginning (cited in the 1st.paragraph) is defeated.

Thermal Plants/steel Plants versus Green Plants: A Cost Benefit Ratio.

Thermal Plant/Steel plant	Green plants
Requires raw materials, water & energy but for which stops working.	Generates its food from air and water and energy from sun.
Gives back harmful gases: CO_2,SO_x,NO_x	Gives back O_2, absorbs CO_2 and SPM
Pollutes water and creates harmful solid waste	Purifies water
Produces goods which require energy to be of further use	Produces food which gives energy when eaten, gives food,fibre,fuel,timber,medicine.
Agent of carbon emission/Global warming	Carbon Neutralizer/Global dimmer

Even an exercise of a Multiple Choice hypothesis, based on Cost/Benefit Ratio, to mine or let the status quo to continue, was faced with dilemma, when the Supreme Court of India, while giving judgment in the famous case of Doon – Valley limestone mining, compared the market value of the limestone reserve to be mined and the total revenue the State would earn by way of tourist traffic, who will visit the Valley to see the beauty of the un-mined mountain slope. The judgment favored the beauty of the Himalayan slope since environment could not be considered as a commodity of transaction.

The vision of development of a region ought to be in terms of renewable resources if the development is to be sustainable. When the tree in front stops the vision of a forest beyond, the act is a delusion. The non-renewable resources can only supplement the developmental efforts. Besides, generation of various types of resources from or on earth ought to be complementary or supportive but not destructive or counteractive to each other, That is, developmental activity should never destroy or eat away into sustainable resources.

Besides, the major benefactors of the earth resources generated from the ground , must be those who have been living over it for generation, that is, even if it be mineral resources, the Project Affected People be the major stake holder. Global trade on earth resources has not only produced "economic terrorism" but has resulted in environmental degradation both at local and global levels, – the end effect is the "Inconvenient Truth" now recognized as "global warming or climatic change". The old fashioned words of M.K.Gandhi that " if man can be satisfied with what the earth offers from the immediate surrounding, most of the present day world problems would not arise" – may not be palatable to modern man but it has meaning for sustainability.

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SIGNIFICANT NEW IRON DISCOVERY AT KURNALPI-RANDALLS AREA, WESTERN AUSTRALIA

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Abstract

Diversified Australian exploration and Development Company (Fairstar Resources Limited) has made a significant potential iron ore discovery at Kurnalpi-Randalls area in Western Australia's eastern goldfield. The discovery has potential to produce Direct Shipping Ore (DSO) with grades >60% Fe and beneficiable materials (BIF) of > 30% Fe. This iron ore discovery is first of its kind in the goldfield area which is located only at a distance of 23 km. from Trans Australian Railway. The BIF structure is located over a length of 15 km. in N-S orientation with an average width of 100 meters.

EXPLORATION RESULTS

Diversified Australian exploration and development company Fairstar Resources Limited has made a significant potential iron discovery at the Company's Kurnalpi–Randalls Project in Western Australia's eastern goldfields.

The new iron discovery was made at the Lindsay Dam tenement 110 km southeast of Kalgoorlie, and is the first of its kind in the area previously known for its gold prospectivity. The tenements are also in close proximity to major rail infrastructure, with the Trans Australian Railway passing 23 km south of the iron discovery. (Figure 1).

The Company has a 100% interest in E28/1677 {*pending*} and in regards to E28/1672 holds the precious metal rights and retains a first to last rights of refusal to purchase for all other minerals.

The Company is of the view that recent rock chip sampling suggests the discovery has the potential to produce Direct Shipping Ore (DSO), with iron grades of greater than 60% Fe, as well as a beneficiable material - banded iron formation (BIF) of greater than 30% Fe grades (Table 1).

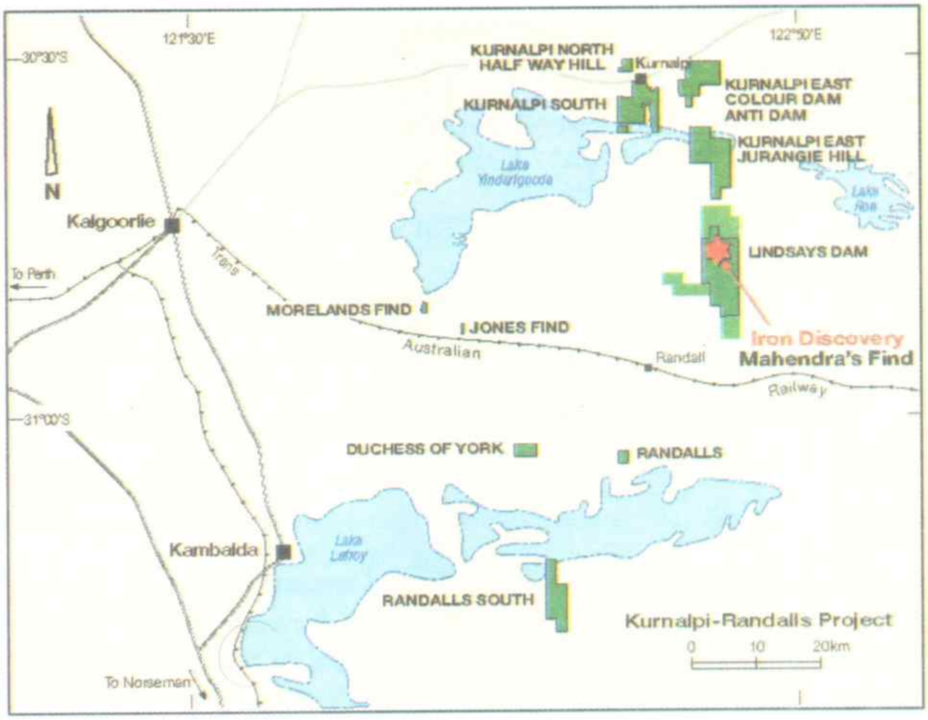

Figure 1: Discovery - location

The host BIF structure at the discovery is in excess of 15km in length and has a north-south orientation. It is highly folded and faulted, four bands of BIFs varying from 10m up to 100m in width have been identified to date. A total of 23 rock chip samples have been collected from the area and analysed for Fe, and other related elements (refer to Table 1).

Commenting on the new iron discovery Fairstar managing director Kevin Robertson said the company was excited to have made such a potentially significant iron discovery at the Lindsay Dam tenement area and was delighted at the iron potential of the tenement.

Aeromagnetic interpretation conducted over the tenement in 1997 by Southern Geoscience Consultants identified the presence of a strongly folded and faulted, moderately to strongly magnetic BIF/chert sequence within the centre of the Steeple Hill Syncline (Figures 2 and 3). It is this magnetic BIF/chert sequence that is the host rock for Fairstar's iron discovery.

Moving forward, the Company will continue with further rock chip sampling as well as conduct more confirmatory work through the acquisition and analysis of available geological and regolith mapping and airborne magnetic and radiometric data, which will then be followed by a planned drilling program and resource estimation. The new discovery will be known as Mahendra's Find.

The Lindsay Dam tenement area and environs were previously explored for nickel and base metals in the early 1970s, after which time the majority of exploration in the area focused on gold.

Table 1: Rock chip sampling results

Sample No	Easting	Northing	Fe	SiO_2	Al_2O_3	P	LOI	Lithology
			----------------Grade %)----------------					
LD001	438105	6594590	45.44	25.81	2.70	0.242	5.20	Goethitic BIF
LD002	438151	6594609	54.10	10.10	5.49	0.023	5.81	Goethitic hematite
LD003	438156	6594636	56.27	10.09	3.84	0.023	4.17	Goethitic hematite
LD004	438171	6594629	58.10	7.43	4.15	0.049	4.48	Goethitic hematite
LD005	438180	6594608	61.21	4.89	3.20	0.02	3.65	Goethitic hematite
LD006	438204	6594610	53.97	12.67	3.84	0.03	4.46	Canga
LD007	438188	6594709	37.41	42.51	2.22	0.013	1.34	Banded Iron Formation (BIF)
LD008	438185	6594739	36.98	41.91	2.84	0.015	1.84	BIF
LD009	438185	6594760	33.88	43.48	4.24	0.013	3.24	BIF
LD010	438147	6594765	32.30	46.74	3.85	0.008	1.92	BIF
LD011	438237	6597544	43.82	31.81	2.23	0.086	2.90	Enriched BIF
LD012	439882	6593549	39.81	36.45	3.25	0.036	2.51	Thinly bedded flaky BIF
LD013	439986	6593678	36.42	42.86	2.07	0.023	0.94	BIF
LD014	439861	6592703	44.68	28.93	3.74	0.051	2.52	Enriched BIF
LD015	437528	6592889	45.87	24.5	2.27	0.306	5.84	Enriched BIF
LD016	437942	6594237	55.83	9.12	4.75	0.044	5.30	Canga
LD017	437787	6594326	43.9	31.05	2.89	0.048	2.6	Enriched BIF
LD018	437978	6594229	59.11	5.56	3.42	0.052	3.81	Canga
LD019	438151	6594570	56.37	7.40	4.51	0.028	5.58	Canga
LD020	438146	6594512	60.77	3.15	5.03	0.034	3.49	Goethitic hematite
LD021	438111	6594447	59.04	6.22	3.23	0.043	4.14	Goethitic hematite
LD022	439375	6588808	53.86	10.30	3.82	0.024	3.46	Canga
LD023	439417	6588825	58.12	7.99	1.83	0.023	3.90	Canga

Legend

High-grade	Fe> 60%	DSO
Diluent	Fe 55-60%	
50-55% Fe 33-50% Beneficiable Material Beneficiable Material		

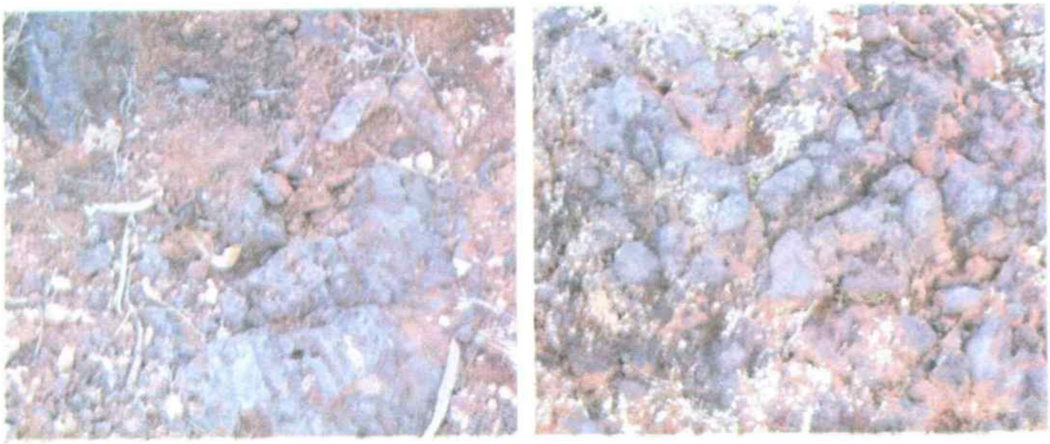

Plate 1: Hematite outcrops

Plate 2: Goethitic hematite outcrops

Plate 3: Canga outcrops

Plate 4: Scree iron ore

Plate 5: BIF outcrops

News about members

- **Sri Subash Chandra Mahala**, a member of SGAT awarded Doctorate Degree in Geology by Utkal University, Bhubaneswar. He was working on **Thermal Springs of Orissa, their Geology, Hydrology, Genesis and Uses** under the guidance of Prof. S. Acharya, Ex. Vice-Chancellor and H.O.D., Geology Department, Utkal University and Dr. P.P. Singh, Reader, Geology Department, Utkal University.

- On the auspicious occasion of celebration of 41st Engineers' Day on 15th September 2008, the **Institution of Engineers (India) felicitated Er. Surendra Nath Padhi, FIE, Member SGAT in recognition of his distinguished and meritorious services and dedicated contributions to the Society.**

  In the citation, among others, mention was made of some of his achievement such as:

  1. First position in India in the First Class Manager's Certificate examination.

  2. Reduction in mine accidents in the areas of his operation so much so that the fatality and serious injury rates of India Mines reached the lowest ever in 1998-99 during his tenure as Director General of Mines Safety.

  3. Expertise in the field of Mine Planning, Safety Engineering, Legislation, Training and Human Resource Development etc.

  4. Authorship of about 80 technical papers presented at National and International Forum.

  5. Being the only person till date to occupy the chair of DGMS which is the highest Govt. post any mining engineer can aspire.

  6. Utilisation of his services by the Central and State Governments as Director of Boards of Public Undertaking and member of High Level Committees, even after retirement from active service.

- **Dr. K.M. Parida,** Scientist, IMMT, Bhubaneswar visited Department of Chemistry, University of Glasgow, Scotland, UK under UK-INDIA collaborative programme, supported by Royal Society, London and DST, Government of India for a period of 3 months to work on the programme entitled "Development of transition metal tantalates and oxynitrides for water splitting and pollution abatement".

- New Members

1. **Shri Rama Kant Mishra**
DGM (Mines)
Nuasahi Chromite Mine
IMFA
PO: Dhanurjaypur, Boula
Dist : Keonjhar
Orissa – 758 078

2. **Mr. Singa Tiu**
Regional Controller of Mines
Indian Bureau of Mines
308, Mahani Complex
Chandrasekharpur
Bhubaneswar - 16

3. **Mr. Turam Balei Munda**
Geologist
C/o Jt. Director, Geology
Zonal Survey, Balangir
At: Shantipara
Po: Rajendra College
Dist: Balangir
Pin: 767002

4. **Mr. Manoj Kumar Oram**
Geologist
Office of the Jt. Director Geology
Zonal Survey , Balangir
At: Shantipara
Po: Rajendra College
Dist: Balangir
Pin: 767002

5. **Mr. Santosh Kumar Ray**
Room No. – 12, Main Building
Central Institute of Mining and
Fuel Research
Barwa Road
Dhanbad – 826 001

6. **Mr. Gopal Chandra Mitra**
Prof., I.I.T, Kharagpur
A/159, Sahid Nagar
Bhubaneswar

7. **Mr. Sanjeev Das**
General Manager (Corporate Affairs)
IMFA Ltd.
IMFA Building
Bomikhal
Bhubaneswar – 10

8. **Mr. Ramakanta Mohanta**
Deputy Director, Geology
O/o Joint Director, Geology
Zonal Survey
At/Po: Sambalpur - 768001
Dist: Sambalpur

9. **Mr. Duryadhan Behera**
Geologist
O/o Joint Director, Geology
Zonal Survey
At/Po: Sambalpur
Dist: Sambalpur
Pin: 768001

10. **Mr. Ratikanta Nayak**
Scientist –'B',
C.G.W.B, SER, Bhubaneswar
H-1/9, Panchashakha Nagar, Dumduma
Plotting Scheme
Bhubaneswar - 19

11. **Dr. Jayanta Kumar Pati**
Reader
Department of Earth & Planetary Sciences
Nehru Science Centre, University of
Allahabad
Allahabad

12. **Mr. Nirmalendu Kumar**
Manager
Uttam Blastech Pvt. Ltd.
Sikandarpur,
Near Hashanganj Middle School
Po: Mirjanhat, Bhagalpur
Bihar – 812005

13. **Mr. Rajesh Chintak**
Chief Resident Executive
Tata Steel
273, Bhouma Nagar, Unit – IV
Bhbaneswar - 751001

14. **Mr. Dwijaraj Dash**
Chief Geologist
Geology and Reservoir Department
Oil India Limited
Duliajan
Assam-768 602

15. **Mr. Sambhunath Singh**
Head Project (BEP&KG)
OIL INDIA LIMITED
IDCO Tower, 3rd Floor
Bhubaneswar

16. **Mr. Kanhu Charan Das**
Gelogist
HIG 1/4, BDA Colony, Kapila Prasad
Bhubaneswar
Orissa

17. **Mr. Mojoj Kumar Sanabada**
Scientist
VIM-784, Sailashree Vihar
Bhubaneswar-751 021

18. **Mr. Suresh Chandra Pal**
Deputy Manager, Geology
Jindal Power Ltd.
At: Thanapada (Behind Town Thana)
P.O: Rangadhipa-770002
Dist: Sundergarh, Orissa

19. **Mr. Dharmendra Sharma**
Geologist
Directorate of Geology
Bhu-Bigyan Bhawan
Bhjubaneswar-751 001

20. **Mr. Mantha Venkata Sanyasi Rao**
General Manager (Geology)
Jindal Steel and Power Ltd.
Plot No. 751, Simillipada
Angul-759 122

21. **Mr. Gangadhar Panigrahi**
Joint Director ogf Geology
O/o Joint Director of Geology
Zonal Survey
Sambalpur

22. **Mr. Nirmalendu Narayan Sing Deo**
Geologist
O/o Joint Director of Geology
Zonal Survey
Sambalpur

SGAT News

- SGAT had organized the Final Day Celebration of **MINERAL DEVELOPMENT QUIZ – 08** on 31.08.2008. A total number of 11 teams representing institutions like Indian School of Mines University, Dhanbad, I.I.T. Kharagpur, Bengal Engineering & Science University, Shibpur, N.I.T Rourkela, IGIT, Sarang, Andhra, Utkal & Berhampur Universities took part in this year's programme. The Mining Engineering team of I.I.T. Kharagpur was adjudged the overall best team.

- **EMAP 2008-09**

  The zonal events are in progress and so far the programme has been completed for 6 zones and the Final Day Celebration is scheduled to be held during January'09 at Bhubaneswar.

- **Vision – 2020**

  SGAT has been entrusted with the assignment of preparing a Vision Document 2020 for Mineral Development in Orissa by the Steel & Mines Department, Govt. of Orissa. Several committees have been constituted for preparing documents on subthemes.

- **Building**

  The official building of the Society is under construction and the roof casting of the 1st floor has already completed. The building is expected to be completed by March'09. Several institutions like OMC, IMFA, Rungta Mines, D.R.Patnaik, S.N. Mohanty & M.G. Mohanty have contributed for the building funds.

- **Award - 2008**

  SGAT Award of Excellence – 2008 is conferred on Prof. G.S. Roonwal, former Prof. of Geology, Delhi University and the award shall be given on 13.12.2008 at Bhubaneswar.

  Sitaram Rungta Memorial Award – 2008 is conferred on Sj. Meda Venkataiah, Executive Director, MSPL and the award shall be given on 13.12.2008 at Bhubaneswar.

- **SUBMISSION OF PAPERS FOR SGAT BULLETIN**
  (Instruction to Authors)

Research papers, review articles, short communications, announcements and letters to editors are invited on topics like geosciences, mineral exploration, mining, materials science, metallurgy, mineral industry and trade, mineral economics, environment, education, research and development, legislation and infrastructure related to mining, mineral policy and mineral development planning.

Submission of manuscript implies that the same is original, unpublished and is not being considered for publication elsewhere. Two copies, complete in all respect (with copies of figures and tables) are required to be submitted. Originals of figures and tables should be enclosed separately. Each manuscript must accompany by a computer diskette (floppy) containing the electronic version of the text. Electronic files of figures, if available, should be submitted in a separate diskette. In each case, the details of software and type of equipment used should be clearly indicated. The copies of manuscripts, strictly in accordance with the instructions to authors given below may be sent to the editor of the bulletin.

Journal Format: **A-4 size**
Language: English
Manuscripts: Manuscripts should be typed in double spacing with wide margins in one side of A-4 size paper either by electronic typewriter or computer (size 12 point Times New Roman font). The title page should include the title of the paper, name(s) of author(s) and affiliation(s). The title should be as brief as possible. An informative abstract of not more than 500 words to be included in the beginning. Not more than 5 key words are to be listed at the end of he abstract. Text of research papers and review articles should not exceed 4000 words. The short communication is for quick publication and should not exceed 1200 words.

Headings: Different headings should be in the following format.
(a) Title: Centrally aligned, bold, capital
(b) Author(s): Centrally aligned, short name, bold, first letter of all words capital followed by communication address (Not Bold)
(c) Abstract: Left aligned, bold
(d) Key words: Left aligned, bold
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(f) Secondary heading: Left aligned, first letter of each word capital
(g) Tertiary heading: Left aligned, first letter of first word capital
(h) Acknowledgements: Left aligned, bold, first letter capital
(i) References: Left aligned, bold, first letter capital
(j) Figure Caption: Left aligned, first letter of first word capital, below the figure
(k) Table Caption: Left aligned, first letter of first word capital, at the top of the table

Illustrations: All illustrations should be numbered consecutively and referred to in the text. They should confirm to A-4 size and carry short captions. Lettering inside figure should be large enough to be accommodate up to 50% reduction. One set of hard copy of all figures (either tracing in ink or laser prints) should be provided in a separate envelope marked "Original Figures". Photographs should be of good quality with excellent contrast, printed on glossy paper. Colour photos are acceptable, provided the author(s) bear the cast of reproduction. Figure captions should be provided on separate sheet.

Tables: Each table must be provided with a brief caption and must be numbered in the order in which they appear in the text. Table should be organised within A-4 size and should be neatly typeset for direct reproduction. Tables will not be typeset by the printer, so their clarity and appearance in print should be taken into account while the author(s) prepare(s) them. Use of 10 points Time New Roman/Arial Font for table is recommended.

References :

(a) References in the text should be with the name of the author(s) followed by the year of publication in parenthesis, i.e. Patnaik

(1996); Patnaik & Mishra (2002); Nayak et al. (2001)

(b) Reference list at the end of the manuscript should be in alphabetical order, in the following format: Sehgal, R.K. and Nanda, A.C.(2002) Palioenvironment and palioecology of the lower and middle Siwalik sub-groups of a part of North-western Himalayas. Jr. Geol. Soc. Ind, vol. 59, pp. 517-529

(c) Articles from the books should follow the format given below:Windley, B.F. and Razakamanana, T. (1996) The Madagascar – India connection in a Gondwana framework. In:Santosh, M. and Yoshida, M. Eds.) The Archaean and Proterozoic terrains of South India within East Gondwana. Gond. Res. Group Mem. No.3, Field Sci. Publ., OSAKA, pp. 25-37

(d) Books should be referred to as:Sengupta, S.M. (1994) Introduction to sedimentology. Oxford and IBH Publ. Co. Pvt. Ltd., New Delhi, 314 pp.

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Reprints: 10 free reprints of each published article will be supplied to the corresponding author. Additional reprints can be ordered through payment at the proof reading stage.

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