Scope for Research in Mining Industry in South India

Welcome Interest Shown by Research Institutes in Mining

The Central Mining Research Institute (CMRI), one among the several national laboratories of the Council of Scientific Industrial Research (CSIR), has been functioning from Dhanbad for the last 47 years. Coal, being one of the major energy resources of the country, is being extensively exploited and it is understandable that the Institute is largely catering to the research needs of the coal mining industry. But coal is not the only one of the major minerals resources of India. Others like iron ore, manganese ore, chromite and a host of metallic and non-metallic minerals of industrial value, scattered in different parts of India, are equally important and require guidance in research related to problems of mining. It is for this reason the decision of CMRI to hold a business meet in Bangalore was to be welcomed. This meeting was held in December, 2004, under the auspices of both the Geological Society of India and CMRI. There was a good gathering of the captains of mineral industries and the meeting was appropriately held in the new building, *"Khanija Bhavan"*, of the Department of Mines and Geology of the Government of Karnataka.

Mineral Industry Largely Export Oriented – Need for Change in Policy

Except the gold mining industry, all the mineral industries are largely export oriented with mining confined to just excavating ore without much processing and its transfer over long distances to the nearest port by rail or road in diesel driven trucks. Years ago, in December, 1968, the Geological Society of India had held a symposium on the Mining Industries of South India at which the economic disadvantage of exporting large tonnages of major industrial ferrous minerals like iron ore, manganese ore and chromite in the raw state was discussed. Nature had been lavish in providing the highest grades of such ore right on the surface and mining did not present any problem. Million and million-tonnes of these ores were exported and no thought was ever given to utilizing them locally. The money earned by such exports was nominal and although providing significant profit to the producers through large scale operations was not adequate to provide even a living wage to the mine worker and poverty continued to stalk the land.

Jamshedji Tata, that great visionary and patriot, nearly a hundred years ago, had the great courage and vision to establish a steel plant at Sakchi in Bihar, centre of the coal belt and the country took a giant step forward. However, mining and export of iron ore in the raw state has not been reduced but continues to gain in momentum, and in the year ended March, 2004, the figure was no less than 57 million tonnes! Steel is presently in great demand, not so much in developed countries like UK, Europe and Japan, but even developing China, which in recent years, has emerged as the biggest producer of steel and consumer of iron ore. Large parts of China are still backward and the requirement of steel for developing infrastructure will continue to grow. Meanwhile India is also growing, requiring ever increasing amounts of steel for developing its infrastructure. Yet, there are no plans for

constructing additional steel plants or for developing mines capable of producing iron ore on a large scale to feed the plants. Existing producers are more interested in selling ores to China because of attractive prices and are reluctant to meet the requirements of steel plants next door.

The Bellary-Hospet area in Karnataka had the richest concentrations of high grade iron ore, analyzing over 63% iron exposed right at the surface but this easily available ore has been indiscriminately mined and exported. The major cost involved is in transport and we see the deleterious effects of fleets of lorries overloaded with iron ore plying on roads over long distances to the nearest port for export to China. The area producing the ore has not only become polluted but has remained as backward as ever. Science and technology has not come to the aid to lessen the hardship of the worker or to reduce the tremendous loss of ore and waste of energy involved in mining and transport.

Research Needed on Alternative Methods of Ore Transport

Years ago I had carried out a survey of the iron ore resources of Mysore (then a part of Karnataka) and prepared a map locating the important deposits. This caught the eye of the American and Japanese engineers who were scouting for good and reliable sources of supply for some of the steel plants that they were planning to put up in Iran. Their attention became focused on the existence of extensive bands of quartz-magnetite ore forming the high ranges of *Sahyadri* (Western Ghats) whose distance to the developing port of Mangalore was just about 40 km. The National Mineral Development Corporation proposed the setting up of a major concentrator plant at Kudremukh, on top of the Ghats, to crush the ore, separate the iron (analyzing over 67% Fe) with the help of magnetic separators and transport the concentrate product in slurry form through a pipeline down the steep seaward slopes of the *Sahyadri*. What appeared to be an impossible task became possible through ingenuity, research and technological skills of a high order. The unique feature of this venture is the transport of 7 million tonnes of concentrate annually in slurry form through pipelines.

The iron ore resources of India, with the solitary exception of Goa, are located over the plateau at elevations ranging from 500 to 1000 m and have to be transported to the ports at sea level. The rest of the mines in India are adopting traditional methods of transport, either by railway over difficult country (like the Dandakaranya line linking the rich ores of Bailadila to the port at Visakhapatnam), or the more reprehensible way of transport of ore by trucks over long distances, ruining roads built at great cost, causing numerous accidents to life and property, causing extensive pollution and consuming large quantities of diesel which could otherwise become available for industrial development. It is a most ruinous method of transporting ore and, to my mind, the country has to think of other means of transport. Slurry transport has been successfully tried at Kudremukh with concentrates either directly fed into the holds of ships or converted into pellets, with only processed ore being marketed. This will be a much more sensible way of transport, avoiding a great deal of human misery and degradation of environment. Our research institutes have to give attention to developing saner and safer methods of transporting ore.

Mine owners argue that when there is a good market for iron ore, why not export it and

reap the benefit instead of leaving the ore in the ground. Their vision, however, does not extend beyond making immediate profit. The larger interests of the country and the overall development of the economy do not bother them. When more steel plants come up in the future, as they are bound to come, and the few existing plants increase their capacity, where is the ore to come from when all the easily available ore has been exhausted through indiscriminate export? Visakhapatnam steel plant is already facing a shortage of iron ore.

Need for Expansion of Steel Production

India today is exporting to other countries no less than 57 million tonnes annually of high grade ore, valued at Rs.42 million and, at the same time, importing 4.1 million tonnes of steel and ferro alloys worth Rs.59 millions. Thus, it is paying more money in importing a small quantity of steel and ferro alloys than it earns by exporting no less than 57 million tonnes of the highest grades of ore. Research institutes and captains of mineral industry should ponder over this fact and set about correcting this imbalance which is progressively making the country poorer. Steel production which is presently at the level of 34 million tonnes is projected to reach 60 million tonnes by 2012 and 100 million tonnes by 2020. But where is the ore to come from? Plans are not ready for the production of large quantities of ore as well as other raw materials required. So far as we know there are no plans for upgrading the low grade ore which the country has in abundance but which requires technological effort of high order. Knowledge is the mother of all resources and a tower of income will grow only when the raw iron ore is progressively converted to pig iron, steel and ferro alloys. The country has to concentrate on developing, producing and exporting finished products like steel rather than raw ore, as making use of the ore is as important as mining it. The annual production of steel is about 34 million tonnes but compare this figure with that of China which has reached the level of over 200 million tonnes. By indulging in the export of high grade raw iron ore all these years we have not only lost millions of tonnes of precious ore but in the process have become poorer and poorer. Our mineral resources have created enormous wealth, not here, but elsewhere in Japan, China and other countries who are importing our ore, turning them into finished products and reselling the same back to us at enormous profit. Raw materials, energy and ingenuity are the main ingredients of wealth of which the country has plenty, but it is yet to realize its full potential and step forward. There should be greater effort at expanding steel production and effecting improvements in the technology of steel making.

Thousands of years ago India was a prosperous country — the textiles produced were of superior quality and in great demand in all parts of the world and large sized diamonds were exported. Numerous gold mines, big and small, were in operation contributing to the rich store of gold in temples and the treasuries of the Princes. It was this wealth which attracted the invaders who came in hordes, repeatedly, and looted the country of all its wealth. Those days are now over but the rich potential of human material, is there awaiting development.

The example of China is before us. In about fifty years they have modernized their geosciences and they have been able to discover mineral deposits of almost all exploitable minerals. With progress in associated technologies of mining and metallurgy they are today

developing into a big power illustrating that creativity is the key to progress, whether in individuals, organizations or societies.

Tardy Progress of the Gold Mining Industry

Another industry which the intellectuals have neglected is gold mining, although over time the yellow metal has always appreciated in value. There are innumerable ancient workings for the metal, large and small, which require to be more thoroughly explored and possibly brought into production. Here again, the tendency is to go in search of large capacity mines neglecting the many small-scale operations which are possible. Liberalisation of policies of government have provided big opportunities in exploration attracting large capital and expertise from outside, but the administrative machinery is so slow that none of the operations which made a start a few years ago with great fanfare have made any significant progress. In the whole of India there is only one producing gold mine as against hundreds operating in China, of which only a few are large scale. China is now the fourth largest producer of gold in the world having realised its importance to the economy and aims to double production each decade. On the other hand, India, in the more than five decades since independence, is now producing only 3 to 4 tonnes of primary gold a year, the result of inappropriate official policies.

Also hardly any attention has been given to the rich potential for gold locked up in sulphide ores. Production of such gold, termed as by-product gold, is now more than the production of primary gold in the country. The copper smelters/refineries erected by the Birla Group and Sterlite Industries to treat imported copper concentrates are reporting an annual production of 5 tonnes of gold and 28 tonnes of silver recovered from the slimes produced during the copper refining process. This is no mean development and by-product gold could be an important source of production, but the exploration agencies have shown no interest in this new source of the metal.

Aluminium Industry

The country has made significant progress in the aluminium industry but here again there has been concentration on exploitation of the highest grade of ore and hardly any attention given to the use of extensive deposits of lower grade bauxite found along the west coast of India. New sources of power have to be found for the development of the industry. Private industry has taken over the bulk of production and is sure to expand its refining capacity.

Gem and Jewellery Industry

A welcome feature is the steady growth of the gem and jewellery industry, which is stated to have risen in value to 12 billion US dollars and is expected to reach 16 billion US dollars by 2009. There is need for a vastly extended programme of diamond exploration and testing of the numerous kimberlite pipes which have come to light in recent years.

In the fast developing scenario, big National Research Institutes should not remain as just show pieces, like the Taj Mahal, but come to the aid of the industry in a big way. 'It is not ore unless you mine it and it is not metal unless you make it'. Research and industry

should get together and until then not much progress is possible. Should we always be waiting for the multi-national companies with their heavily paid top management which contribute to the wealth but displace and drive away the local people who own the land denying them even a small moity of the profits earned. People of the land remain backward and poor, sharing none of the benefits of the industry. Laws framed during colonial rule remain unchanged.

Non-ferrous Mineral Industry

There is scope for greater effort in the growth of the non-ferrous mineral industry. It had taken more than fifty years for the public sector to produce just 50,000 tonnes of copper a year, hardly sufficient to satisfy even a quarter of the requirement of the country. As soon as the liberalization policy was announced there has been a great spurt in activity with several large-sized plants coming up through private initiative along the coast, importing and treating copper concentrates and producing enough refined copper not only to satisfy our internal needs but also to export significant quantities. Production in one plant in Gujarat has already touched 185,000 tonnes a year and is projected to be expanded to 250,000 tonnes. This major development has gone unrecorded by the Indian Bureau of Mines, the official agency which should provide relevant information on all new developments! Birla copper has boldly ventured to acquire viable properties in outside countries and is poised to become a global competitive producer. The company has a precious metal refinery that produces gold and silver from anode slimes. This speaks of the efficiency of the private organization as against the lethargic ways of central government control with no free scope to the management to develop new ways and encourage new talent. Research institutes too have shown no interest in making the country self-sufficient in her requirement of metals.

In the final analysis mineral development should benefit the largest number of people. Increased development of iron and steel, aluminium and copper, cement and ceramic products should contribute to our prosperity and just not make individuals (who are probably already rich) richer. The developments should be directed at improving the living standards of the large majority in rural India.

Natural resources in India should be regarded as satisfactory, but what is highly unsatisfactory is the way we have exploited these resources to our benefit. Half-hearted efforts will not take us very far and there is great need for determination both on the part of the industry and the institutes of research in training the right personnel to make the country self-sufficient in her requirement. If our production is to be maintained and improved, a very large effort is needed to produce more energy with greater attention given to the development of coal in Andhra Pradesh, lignite in Tamil Nadu and Gujarat.

The label that India is a poor country is often heard and the statement is true with widespread poverty stalking the land. Dependence has no doubt given way to independence but prosperity is yet to seep to lower levels and eliminate poverty. This is largely dependent on the way we utilize our mineral resources more of which must be found and every effort should be concentrated towards this goal. There is at present too much slackness in the field

of mineral exploration and the major investments required are not forthcoming while scientists, too are not exposed to the spectacular developments taking place elsewhere. It is also not just a question of finding the resources – they have to be mined and, what is more important they should be used in the country and not just exported in the raw state, but converted into metal which is badly needed to sustain increased industrial activity. Research Institutes have an important role to play in ensuring that this comes about.

There should aslo be greater concern about our resource adequacy as there is a perceptible slowing-down in our exploration activity and this should not be. Massive investment on exploration is necessary. Compared to the vast investments which governments, as well as private industry, are earmarking for exploration, especially in Australia and Canada, our investments in this sector are negligible and there is great scope for improvement.

Give Generously for Research

In the developed nations of the world, individuals and mineral corporations have endowed vast amounts of money for research. Andrew Carnegie of USA, who made his fortune in steel making earmarked a considerable part of his wealth for setting up libraries in as many as 200 centres in all parts of the world. Hopkins donated his entire fortune to the setting up of John Hopkins University which is now a world famous institution. Alexander Fullerton Penrose endowed his entire fortune to the Geological Society of America, to make it one of the most important geological institutes of the world. Nearer home, we have the example of Narendra Kumar Baldota who has liberally donated Rs. 12 lakhs to the Geological Society of India to enable it to have a habitation of its own. Industrial corporations and individual mine owners could extend their helping hand by enrolling as Corporate Members of scientific societies.

The illustrious example of Jamshedji Tata earmarking a greater part of his fortune in the setting up of the Indian Institute of Science, which has played and is playing no insignificant part in training leaders to man the research institutes in the country is before us. Tata had the vision to institute scholarships for bright students to go abroad and be trained in prestigious institutes of research. Raja Ramanna, Jayant Narlikar and the present chairman of the CSIR Raghunath Mashelkar were all "Tata Scholars". Industrial houses should set apart a portion of their profits for research, as such investments will not be wasted but will return to them hundredfold and contribute to the building of a prosperous India.

It is necessary to have a programme for tomorrow. What is now required is a determination to forge ahead, not being content in just mining and exporting raw ore without realizing that by so doing we are postponing our ability to produce all that we need. The building of a prosperous India through the development of mineral resources is the biggest challenge yet faced by India. In bringing about this transformation, research Insfitutes, like the CMRI and the captains of industry should collaborate, develop indigenous technology and pave the way for a better and prosperous tomorrow.

B. P. RADHAKRISHNA

Tsunami News

Tsunamis Affecting India (T.S. Murthy, Canada, Columbia University Science Bulletin)

Although the majority of the reported tsunamis are from littoral countries of the Pacific Ocean, there are a few cases of tsunamis in the Indian Ocean. The approximate length of the Indian coast is about 6000 km. The coasts run from north to south and have two arms in the east and the west with the tapering end at Kanyakumari. The tsunamigenic earthquakes occur mostly at the following three locations: (1) Andaman sea, (2) Area about 400-500 km SSW of Sri Lanka (Ceylon) and (3) the Arabian Sea about 70-100 km south of Pakistan Coast – off Karachi and Baluchistan. The oldest record of tsunami is available from November 326 BC earthquake near the Indus delta/Kutch region. Alexander the Great was returning to Greece after his conquest and wanted to go back by a sea route. But an earthquake of large magnitude destroyed the mighty Macedonian fleet as reported by Lietzin (1974).

The earliest record of tsunami is reported to be about 1.5 m at Chennai (formerly Madras) which was created due to the August 8, 1883 Krakatoa volcanic explosion in Indonesia. An earthquake of magnitude 8.25 occurred about 70 km south of Karachi (Pakistan) at 24.5 N and 63.0 E on November 27, 1945. This created a large tsunami of about 11.0 to 11.5 metres high on the coasts of India in the Kachchh region, as reported by Pendse (1945).

The Tsunami of 1941 Following an Earthquake in the Bay of Bengal was Detected in Sri Lanka (http://www.asc.ind.org/menu/)

The earthquake of 26 June, 1941 is among the strongest earthquake ever recorded in the Andaman & Nicobar Islands. It had the magnitude of 7.7 (Mw).

It was centred in the Bay of Bengal, roughly, 20.5 km W of Flat island, India or 23.6 km WNW of Yadita (Middle Andaman Islands), India; or 96.7 km NNW of Port Blair (South Andaman Island), India; or 617 km SW of Yangon, Myanmar; or 834 km NNW of Band Aceh (Sumatera), Indonesia

It was the last earthquake in the Andaman and Nicobar Islands. The 1881 Nicobar Islands earthquake (m 7.9) is the only other event of comparable magnitude.

This 1941 earthquake caused widespread damage on Middle and South Andaman Islands. Most masonry structures in and around Port Blair were badly affected. The Cellular Jail which was a 3 storey building with 696 solitary cells and infamous for the imprisonment, torture and murder of freedom fighters, including Vinayak D. Savarkar was destroyed as were all the elegant buildings and wide roads, on Ross Island, the administrative center of the British. The maximum intensity was experienced in Baratang island, Shoal Bay creek, north of Port Blair and near Port Anson.

Tremors from the earthquake were felt in cities along the Coromandel (eastern) coast of India and even in Colombo, Sri Lanka. In Madras (now Chennai), two tremors were felt, the first of 2 seconds and the second lasting 15 seconds. It was felt throughout the city, mostly by people in tall buildings. At some locations, doors and windows are reported to have "slammed with a bang" and "chairs rocked". Articles kept on shelves also fell onto the floor. The tremors in the city were reported to have been the strongest since 1899. At Visakhapatnam, two shocks were experienced within two minutes. People went outdoors on feeling the tremors, as did employees at the Municipal buildings in the city, as they felt

the buildings rocking. People outdoors are said to have had an "unusual experience". Tremors were also experienced at Calcutta (now Kolkata), Chandernagar and Cuttack. Shaking was felt for a duration of 4 minutes at Cuttack. Tremors were felt in Colombo, Sri Lanka for a few seconds and also at Syhlet, Bangladesh where the Car Festival was suspended due to the quake. There are no reports of tremors being felt from Sumatera, Indonesia in June 1941.

The earthquake was followed by several powerful aftershocks. Two magnitude 6.0 events struck within 24 hours of the main shock on June 27, 1941. The first occurred at 07:32:47 UTC and was followed by another at 08:32:19 UTC. These were then followed by 14 earthquakes of magnitude 6.0 up to January 1942.

Tsunami: Preparedness and Warning (George Pararas Caraynies)

There is very little that can be done to prevent the occurrence of natural hazards. But while these natural disasters cannot be prevented, their results, such as loss of life and property, can be reduced by proper planning. Government agencies should formulate land-use regulations for a given coastal area with the tsunami risk potential in mind, particularly if such an area is known to have sustained damage in the past. Tsunami hazard perception by the people of a coastal area is necessary in mitigating loss of life and damage to property. Hazard perception by the public is based on a technical understanding of the phenomenon, at least at the basic level, and a behavioral response stemming from the understanding and confidence of the public for the authorities responsible for warning.

Over warning, based on inadequate data on which to base the prediction, often leads to false alarms and lack of compliance with warning and evacuation attempts. Such false alarms result in a loss of faith in the capability of a warning system and result in reluctance to take action in subsequent tsunami events.

Fortunately, forecasting of tsunami in recent years has been quite good and the image of the Tsunami Warning System and its credibility have improved considerably. Forecasting, however, is not an exact science as the phenomenon itself is very complex and data on which the forecast is based may often be inadequate for certain areas of the Pacific.

NASA Details Earthquake Affects on the Earth (NASA: News Release 2005-009; 10 Jan. 2005)

NASA scientists using data from the Indonesian earthquake calculated it affected earth's rotation, decreased the length of day, slightly changed the planet's shape, and shifted the north pole by centimeters. The earthquake that created the huge tsunami also changed the Earth's rotation.

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Gross and Chao have been routinely calculating earthquakes effects in changing the Earth's rotation in both length-of-day as well as changes in Earth's gravitational field. They also study changes in polar motion that is shifting the North Pole. The "mean North Pole" was shifted by about 2.5 centimeters (1 inch) in the direction of 145 degrees East Longitude. This shift east is continuing a long-term seismic trend identified in previous studies.

They also found the earthquake decreased the length of the day by 2.68 microseconds.

A Resolution of the International Union of Geological Sciences (IUGS)

The International Union of Geological Sciences (IUGS), recognizes:

1. That tsunami warning system in the Pacific Ocean have proven to be effective over several decades, that no such comprehensive system exists for the Indian or Atlantic Oceans, that such systems employing traditional and new space-based technologies in these oceans could prevent loss of life if predictions were timely and warnings were heeded.
2. That tsunamis are triggered not only by earthquakes, but also by volcanic eruptions and landslides; and that these hazards, especially landslides, extend to all oceans and their margins.
3. That on-land landslides, earthquakes, floods and volcanic eruptions constitute significant potential for natural disasters, and that terrestrial landslides are perhaps the most damaging of all.
4. That a substantial portion, if not most, of the global human population resides in areas of characterized by significant risk of the occurrence of natural disasters.
5. That the tendency of the International Community to concentrate on reaction to natural hazards, rather than on preparation and their mitigation, operates to increase their cost to amounts much greater than that of preparation and mitigation.
6. That the lack of education in and awareness of Geological Sciences worldwide tends to decrease awareness of the possibility of natural disasters and thus exacerbate their human and economic toll when they inevitably occur.
7. That in the aftermath of a natural disaster, widespread knowledge of the geological sciences and of existing technology could assist rescue agencies and civil defense managers to obtain faster understanding of the extent of the damage from the event and how to cope with it.
8. That the reduction of the predictive uncertainty of a natural disaster is the most important issue in natural hazards reduction, but that reduction requires a thorough understanding of the nature of the geological processes giving rise to the disaster.

The IUGS Recommends:

1. That systems and procedures be established for early warning, developing public awareness including Geological Science education, regional evacuation routes, and shelters with locations based on appropriate geological information, including maps of existing geological hazards.
2. That comprehensive education in the Geological Sciences, including knowledge of local geological hazards and their risk, become an integral part of education system at levels and in all countries.
3. That regional disaster management systems be organized where they do not exist, and that existing disaster management systems be made more effective, and that these systems take steps effectively to monitor known indicators of all natural disasters.
4. That multidisciplinary and multinational research programs and research networks on geological hazards and risks be developed to improve the professional and pubic awareness of and understanding of the phenomena associated with such hazards, and that efforts be increased to develop forecasting capability of such hazards and

The IUGS Resolves:

1. To promote the development of application of scientific expertise and experience in understanding the geological forces at work in the development of all types of natural hazards and the processes involved in their mitigation of natural hazards.
2. To share this information as freely as possible with other members of the scientific community, government officials, policy makers and planners, the insurance industry, and the public as a whole.

Tsunami Early Warning System May be of Little Help (*Daily Telegraph*, 31 Jan. 2005)

In the early morning of Boxing Day, thousands of people witnessed one of the earliest phenomena known to science. Before their eyes, the Indian Ocean began to withdraw from the shore, like a scene from a Cecil B. DeMille epic. Many watched it with incredulity; some even ventured on to the beach to look at what had been revealed by the receding sea. What all too few realized was that the retreat presaged the imminent arrival of a tsunami.

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The quake's magnitude and the tsunami risk were still unclear by about 3.30 am, when news reports began to emerge of a giant wave striking Sri Lanka. It took several more hours before it could be confirmed that the quake was of cataclysmic proportions. Recognising the threat to east Africa, the State Department instructed its embassies to alert local governments. That probably saved many lives; in Kenya alone, 10,000 people were evacuated from the beaches around Mombasa before the waves struck. Only one person is reported to have drowned.

The disaster has inevitably focused attention on establishing a tsunami alert system for the Indian Ocean. Costing 50 million pounds, it would link seismic detectors with pressure-wave sensors. Such a system has been operating in the Pacific for decades, and has highlighted the huge challenge in forecasting rare events: Since 1948, three out of four tsunami alerts have proved to be false alarms.

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The Indian Ocean so far less prone to tsunamis than the Pacific, so any warning system there is likely to suffer a far higher rate of false alarms. Without adequate planning and education, the result is likely to be chaos or apathy. On Thursday, aftershocks from the original quake led to a tsunami alert in India, causing stampedes in the coastal region of Kerala. It proved to be a false alarm.

In Wake of Disaster, Scientists Seek out Clues to Prevention (*Science*, no.5786, 7 Jan. 2005)

A week after the tragedy, the question of how many lives might have been saved had authorities in those countries recognized the danger in time to evacuate their coasts remains unanswered. But it's a hypothetical question, because the information needed to take such steps doesn't exist. That's why researchers are gearing up for an international data-collection effort in the affected countries, aimed at improving models of how tsunamis form and setting up a warning system in the Indian Ocean. "This was a momentous event both in human and scientific terms" says Costas Synolakis, a Civil Engineer and tsunami researcher at the University of Southern California in Los Angeles. "It was a failure of the entire hazards-mitigation community."

As relief efforts continue, scientists are traveling to the ravaged coasts to survey how far inland the water ran up at different points along the shore lines, how tall the waves were, and how fast they hit. In additions to providing detailed picture of the event, says Philip Liu, a tsunami expert at Cornell University who is flying to Sri Lanka this week, information from these field surveys will enable researchers to test computer models that simulate the propagation of tsunami waves and the pattern of flooding when they break upon the shore.

Testing and refining tsunami models would increase their power to predict future events – not just in the Indian Ocean but elsewhere, too, says Vasily Titov, an applied mathematician and tsunami modeler at the Pacific Marine Environment Laboratory in Seattle, Washington.

Such predictions would be easier to make if ocean basins resembled swimming pools and continents were rectangular-shaped slabs with perfect edges. But the uneven contours of sea floors and the jagged geometry of coastlines make tsunami modeling a complex engineering problem in the real world.

Tsunami Warning Centre Likely in Hyderabad (*The Hindu*, 22 Jan. 2005)

A Tsunami warning centre, proposed to be set up by the Centre, is likely to come up in Hyderabad on the campus of the Indian National Centre for Ocean Information Services. It is expected to become operational by September 2007, with the key elements put in place by March 2006. It is estimated to coast Rs. 125 crores.

The Union Science and Technology Minister, Kapil Sibal, told presspersons at the end of a two-day brainstorming session organized by the Centre and attended by experts from within and outside the country, that it would be in the nature of a multi-disaster warning system, addressing issues like fine-tuning of the forecast for storm surges caused by cyclones and preparation of seawater inundation and vulnerability maps for coastal areas. The establishment of the system would involve deployment of a comprehensive real time ocean observation network comprising sea bottom pressure recorders around the two well-known zones of the Indian Ocean region, which are capable of producing tsunamis: the Java-Sumatra region in the eastern part of the Indian Ocean, and Makaran region in the northern edge of the Arabian Sea. In addition, it is envisaged to upgrade the network of seismic stations within the country to provide for near real time determination of the various parameters of earthquakes occurring in the two zones.

Helping the Survivors (*The Economist*, 8 Jan. 2005, p.9)

The world's response to the horrors wrought by the Indian Ocean tsunami has been extraordinary. As well as offering up their sympathy and prayers, people everywhere have dug deeper than ever into their pockets. The task now will be to make that generosity count, in an enduring way.....

.... All of which is entirely welcome: an uplifting start to the new year after the old one ended so badly. Even so, the response to the tsunami prompts some big, difficult questions. Will the money be well spent? Is it at the expense of other deserving causes and political priorities? If so, is that justified? Or, to be optimistic, might so much generosity actually reflect a change in the priorities of rich countries that could benefit all developing countries, not just those hit by the recent disaster? .....

More Generous than Thou (*The Economist*, 8 Jan. p.28)

...Hopes and fears, however, do not rest on cash alone. If good is to come of the disaster it will come of wider lessons learned. The lateness of the response, the lack of an early warning system, the paucity of rapid-reaction units and the absence of an overall relief co-ordinator all demand solutions....

Sorry Isn't Good Enough (*India Today*, 17 Jan. 2005, p.19)

The first axiom of effective disaster management is to have an early warning system in place that would, among other things, provide a good enough estimate of the magnitude of the damage caused. Despite having enough equipment to monitor earthquakes and supporting one of the largest scientific fraternities in the world, all this expertise added up to nought that terrible Sunday morning. Any earthquake of magnitude of over 7 on the Richter scale in the region should have set the concerned government agencies scrambling. They didn't. The delay meant that not only did the monster wave strike without warning but that even five hours later there was no proper estimate of the true magnitude of the tragedy. Worse, weeks later in places like the Andaman and Nicobar islands we continue to have only guestimates of the death toll....."

Sumatran Earthquake Spawns Devastating Tsunami (*EOS*, v.86(1) 4 Jan. 2005)

"The tsunami community is in awe of the magnitude of this event. This very small and highly specialized community needs the brain power of the entire Earth science community to help understand and tackle this problem so that we can avert these colossal disturbancesto our societies."

..The earthquake is providing a good opportunity for scientists to study the Earth's interior, becacuse the seismic waves from the quake have travelled through and around the globe many times. Satake noted that the 1960 M9 earthquake in Chile significantly advanced the understanding of the Earth's free oscillation.

Central, Inter-ministerial Disaster Management Agency (*Frontline*, 28 Jan. 2005, p.4, 8)

Although the massive undersea earthquake of Richter 9 off the coast of Sumatra early that morning was registered in seismic laboratories in different parts of the world, warning were not passed on to those who were going to be victims of its deadly impact, as the New York Times writer Andrew C. Revkin's says: "This failure of human accountability, with all its tragic consequences, must surely be investigated if the lessons of the biggest natural disaster in living memory are to be learnt.....

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The decision to set up a dedicated, centralised inter-ministerial disaster management agency was taken in princple by the Central government in August 2004, yet another example of good intentions that were not acted upon until it was too late. Disaster Management –A Status Report (August 2004) is a document prepared by the government in the light of the experience of the Bhuj earthquake. Its recommendations unfortunately remained just where they were — on paper. It recommends the establishment of a National Disaster Management Authority under the Ministry of Home Affairs. A disaster management system, the report says, must have a "modern, permanent national command centre" with communications and data links to all State capitals. Such a system requires unified legislation and linkages down to the State, district and taluk levels as well as to external disaster management agencies. The Report also sets out the mechanism by which relief and rehabilitation are to be financed.