

Adoption of UNFC System and its Application to Solid Mineral Commodities — Indian Experience

by

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Introduction

Country-specific classification systems for mineral resources suffer from certain limitations on account of language, nationality of definitions etc. The United Nations Framework Classification (UNFC) system, in contrast, aims at a universal system communicable and understandable across national boundaries. This system assumes particular relevance in this era of economic globalisation, wherein transnational investments in exploration and mining have become order of the day.

In India, there is a large number of minerals of which exploration has taken place at one time or other since long, and also the national mineral inventory database maintained by the Indian Bureau of Mines (IBM) for 64 noncoal solid minerals, by the Geological Survey of India (GSI) for coal and lignite, and by the Department of Petroleum & Natural Gas for oil and natural gas. The long history of mineral exploration apart, there is a long history of production of as many as 84 minerals. There is a large number of agencies — government and private, which are engaged in mineral exploration and production activities, which are used to the traditional Indian system of classification of resources, and whose activities are governed by a set of Central and State acts and rules. And India is the second most populous and the largest democratic country in the world with authorities decentralised to a great extent as far as mineral sector is concerned. Thus, in India, changing to a new system from a long established system is beset with a host of complexities. But, in spite of the complexities of the task, considerable progress has been made in India towards switching over to UNFC system, insofar as solid minerals are concerned.

Mineral Administration and Resource Estimation in India

General :- India is a country of over 1 billion population, land area of 3.28 million square kms, off shore area of 2 million square kms (with possibility of another 1 million square kms of Continental Shelf area being added) and a coastline of 2750 nautical miles. There are 29 states and 6 union territories within India. The total Gross Domestic Product (GDP) at current prices was about US \$ 465 billion in 2000. The total gross value of mineral production (excluding input costs of mining) during April 2001 - March 2002 was Rs. 595

billion (approximately US \$ 13 billion) covering around 80 nonatomic minerals. Calculated as per the standard procedure of deducting mining input costs, the contribution of mining and quarrying sector in the GDP worked out to 2.3% during April 2001- March 2002. The total export value of ores and minerals during April 2000 – March 2001 was Rs. 344 billion (approximately US \$ 7.5 billion) accounting for about 17% of the total value of all merchandise exported from India. During the same period the total import value of ores and minerals was Rs.9.65 billion (approximately US \$ 21 billion) accounting for about 42% of the total value of all merchandise imported into India. The number of reporting working mines as on 31st March, 2002 was 3078 plus thousands of nonreporting working and idle mines.

Legislative system :- Under the Indian Constitution, while State is the owner of mineral resources, the union Government has powers to make laws regulating exploration and mining. The solid minerals are broadly classified as (1) minor minerals and (2) other than minor minerals or “major” minerals. Examples of minor minerals are granite, marble, sandstone, slate, bentonite, fuller’s earth, road metals, brick earth etc. while major minerals include coal, iron ore, base metals, bauxite, rock phosphate etc. There is a multiplicity of law concerning exploration and mining activity in India:

- (1) Mines Act (mainly concerned with safety of workers)
- (2) Oil Fields (Regulation & Development) Act (mainly for regulation of exploration and mining of oil and natural gas).
 - Petroleum Concession Rules.
- (3) Atomic Energy Act (Stipulates some special conditions for atomic minerals).
- (4) Mines & Minerals (Development & Regulation) Act (MMDR Act) (mainly for all solid minerals onshore)
 - Mineral Concession Rules (MCR)
 - Mineral Conservation & Development Rules (MCDR)
 - Granite Conservation & Development Rules (GCDR)
 - Marble Development & Conservation Rules (MDCR)
 - Separate Minor Mineral Concession Rules (MMCRs) of each State.
- (5) Coal Mines (Conservation & Safety) Act.
- (6) Offshore Area Mineral (Development & Regulation) Act.
- (7) Various other Acts concerned with welfare of labour.

So far as solid minerals in land are concerned, the MMDR Act regulates the exploration and mining activities. It provides for 3 types of concessions

namely Reconnaissance Permit (RP), Prospecting Licence (PL) and Mining Lease (ML). The areas not under ML, are called “free hold areas” and RPs and PLs are granted only in such areas. But resource assessment may take place at any of the above stages. Some government organisations like the GSI, Directorates of Geology & Mining (DGM) of various state governments, etc. can carry out exploration work and resource assessment without formally taking RP or PL. This Act also provides for ‘mining plans’ of which preparation and getting IBM’s approval is the responsibility of the prospective entrepreneur who wants ML. A mining plan must, inter alia, contain estimates of resource properly classified under different categories as per guidelines issued by IBM.

So far as noncoal major minerals are concerned, all resource estimations in mines are required to be properly classified, recorded and reported to IBM under MCDR. For coal, there is no such statutory stipulation. So far as minor minerals are concerned, there are specific stipulations for reporting of resource estimates to IBM in case of granite mines (under GCDR) and marble mines (under MDCR). For other minor minerals, the state governments are solely responsible and the Union Government has no role on this issue.

The Offshore Area Mineral (Development & Regulation) Act is a recently notified act (31st January, 2003), and in future, if and when offshore exploration and mining activity starts, it will be the obligation of the licencees and lessees to report to IBM, data on resource estimations.

Administrative System :- There is a multiplicity of governmental agencies concerned with administration of different acts and rules and with different responsibilities related to exploration, mining and resource estimation:

- (1) Union Ministry of Mines : Responsible for grant of concessions, regulation and development of mining of all noncoal solid minerals.
 - (i) I.B.M. : Administration of MCDR, issue of guidelines for and approval of mining plans for noncoal nonatomic major solid minerals, resource estimation in noncoal nonatomic major solid mineral mines, preparation and maintenance of national inventories of noncoal solid minerals for both freehold and mining lease areas, maintenance of statistics for mines and minerals. In future, responsibility of regulation and development of mines of all solid minerals in off shore areas.
 - (ii) G.S.I. : Geological mapping, preliminary and general exploration in both on-shore and off-shore areas on promotional basis, preparation and maintenance of inventory of coal and lignite.
 - (iii) Mineral Exploration Corporation : A public sector exploration company engaged in detailed exploration of

selected deposits of solid minerals on both promotional basis and commercial terms.

- (iv) Public sector mining companies : Detailed developmental exploration and mining in a few mines of copper, bauxite.
- (2) Union Ministry of Coal : Responsible for grant of concessions, regulation and development of coal mining.
- (i) Department of Coal : Approval of mining plans.
 - (ii) Coal Controller : Collection and maintenance of statistics.
 - (iii) Central Mine Planning and Design Institute : A public sector company engaged in detailed exploration of coal mining blocks.
 - (iv) Public sector coal mining companies engaged in mining of coal deposits.
- (3) Union Ministry of Steel :
- (i) Public sector mining companies engaged in detailed developmental exploration and mining in the mines of some steel input minerals (e.g. some of the iron ore, manganese ore, limestone, dolomite mines).
- (4) Union Ministry of Petroleum & Natural Gas : Responsible for grant of concessions, regulation and development of exploration and mining activities — both onshore and offshore, maintenance of statistics related to oil and gas, partly exploration and production of oil and gas.
- (5) Union Ministry of Fertilizer and Chemicals : Detailed developmental exploration (partly) and mining in some mines of pyrites, phosphorite.
- (6) Union Ministry of Labour :
- (i) Directorate General of Mine Safety : Mainly concerned with safety and welfare of all mine workers, but also has some role (jointly with IBM) in approval of mining plans for noncoal, nonatomic, major solid minerals.
- (7) Department of Atomic Energy : Has some special powers related to atomic minerals; also general and detailed exploration for atomic minerals, and mining of some atomic mineral deposits through public sector mining companies.

- (8) 29 State Governments : Responsible for grant, regulation, and development of all minor mineral licences and leases in onshore areas.
- (i) DGMs or its equivalents : General exploration for all solid minerals.
 - (ii) Public sector mining companies : Development and mining of some major and minor minerals.

System of Exploration and Resource Estimation :- As can be seen from the earlier account, there are at least 5 Union Government agencies, 29 state government agencies, a number of Union and State Government mining companies, besides about 3000 private sector working mines and many idle mines — all are engaged in exploration, development and resource evaluation of solid minerals for different objectives, in either freehold or leasehold areas. The objectives can be preparation of mining plans, fulfilment of statutory obligations of reporting resource data to IBM, improvement in the knowledge base of the mineral wealth of the country, national planning for resource development and management, etc. Besides, there are dedicated ministry and agency for exploration of oil and natural gas. So far as the solid minerals are concerned, the exploration programmes and activities of all Union and State Government agencies are coordinated through the mechanism of the State Programming Board of each state, and finally the Central Geological Programming Board.

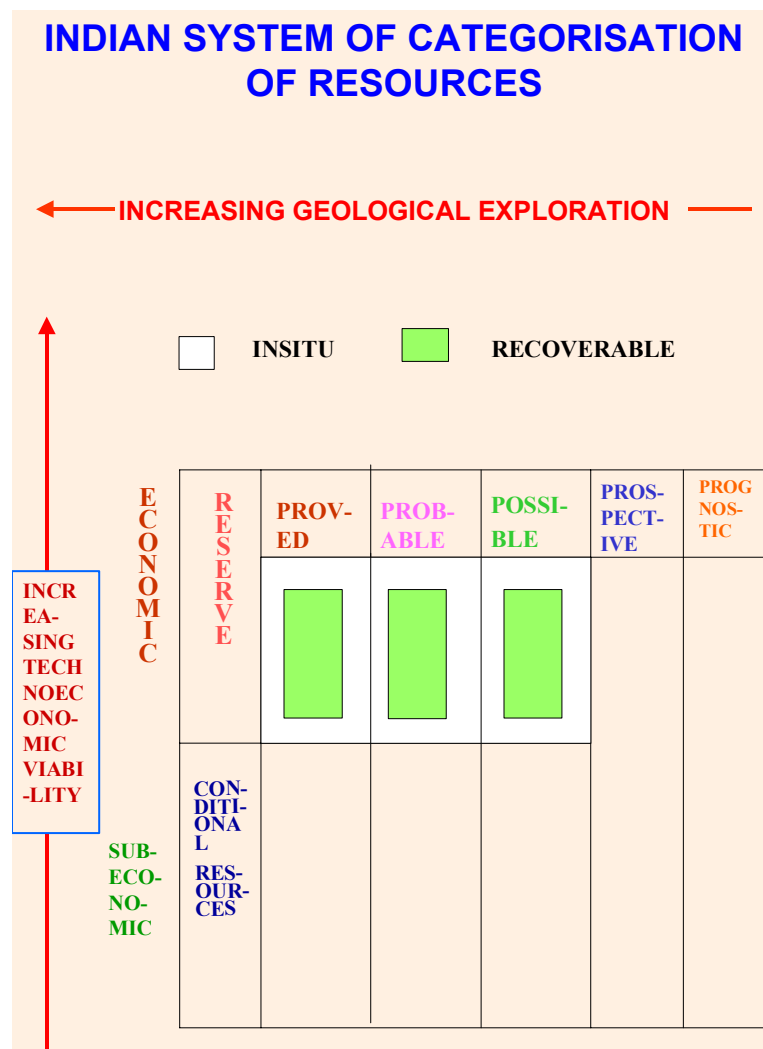
Consequently, the same deposit may be explored by different agencies at different stages or by the same agency at different times. This may happen with change of land status from freehold to leasehold or without change. But the net result is that in the same deposit, at any point of time, resources in different parts may be estimated under different categories at different confidence levels. The resource estimation is a dynamic exercise, and the categories tend to progress from “resource” to “proved reserve”, and conceptually, the exercise can never be assumed to be complete until either the entire deposit is explored in details with reserve under the highest category, or the entire deposit is mined out.

National Mineral Inventory :- The output of all exploration, and mining activities by all agencies at all times goes to form the input for national mineral inventories. In India, the mineral inventories are at present maintained in 3 organisations. The inventory of onshore noncoal solid minerals is the responsibility of IBM (over 16,000 deposits, leases and mines of 64 minerals covered at present and updated quinquennially); that of onshore coal and lignite is of GSI (annual); while that of petroleum and natural gas — both onshore and offshore updated every year by the Ministry of Petroleum and Natural Gas; and the summaries of all the inventories are published by IBM. An inventory at a particular point of time, reflects the up-to-date results of all exploration and mining activities (which, inter alia, include reserves and resources classified into categories according to the prevailing Indian system) carried out for years and

decades, till that point of time. These inventories form the basis of national planning, policy formulation, exploration programming, and also various micro-level decisions (e.g. infrastructure, investment etc.) pertaining to mineral sector. The national mineral inventories serve as the mirror of the resource classification system in vogue in India at any point of time, and any change in this will ultimately have to reflect itself in the inventories.

Indian and UNFC Systems

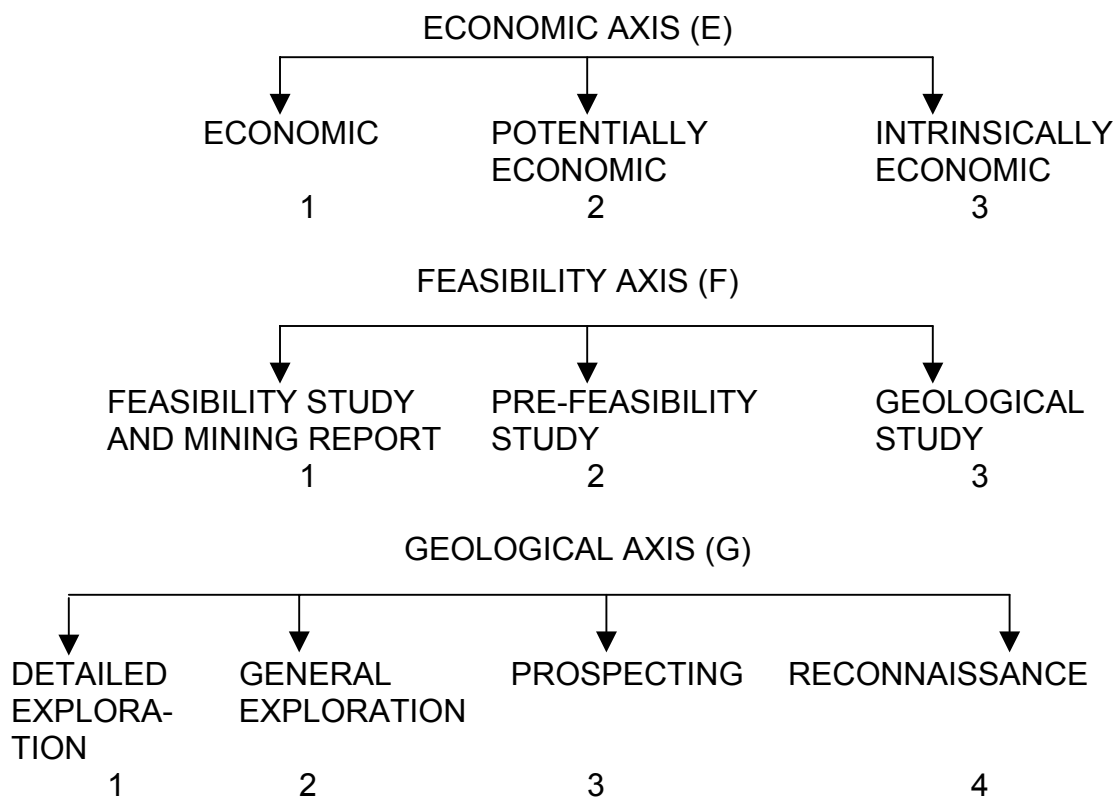
Indian System : Prior to 1981, there was no nationally accepted system in India. Different agencies followed different system — USGS, Russian etc. — terminologically and (to a large extent) definitively also. In 1981, a system was standardised which underwent minor modifications later on to fit in with the practical data collected for the National Mineral Development database of IBM. This system is schematically shown as follows:



As can be seen, the system is 2-dimensional — with no distinction between technical and economic, and with an emphasis on geological axis. The parameters are also very few and, to a great extent, subjective. For geological axis the parameters are primarily spacing of the observation points (e.g.

boreholes, pits, trenches), scale of geological maps, and inferences drawn therefrom. The techno-economic parameters are grade, amenability to beneficiation, thickness and depth (more particularly in case of coal) and some general conditions of constraints of environment, forest, market etc. After a laborious and prolonged effort comprising training, conferences and interactions through the instrument of national mineral inventory, this classification system percolated down to the level of individuals and organisations concerned with exploration, mining, planning and administration in the mineral sector of India, and now, since 1981, is firmly entrenched in the Indian mindset.

UNFC System : UNFC is a 3 dimensional system, the 3 axes being economic, feasibility and geological. The categories of resource estimation are denoted by digital codes as follows.



Thus, the codes of categories can vary from the highest (111) to the lowest (334). The standard terms along with their codes are as follows.

Terms and Codes in UNFC

1.	Total Mineral Resource (Intrinsic economic interest, reasonable prospect for eventual economic extraction)	Measured Indicated Inferred	(331) (332) (333)
2.	Mineral reserve (economically mineable part of measured/indicated mineral resource)	Proved Probable	(111) (121 & 122)
3.	Reconnaissance Resource		(334)
4.	Pre-feasibility Mineral Resources		(221, 222)
5.	Feasibility Mineral Resource		(211)

The UNFC system is relatively more objective, and because of the use of numerical codes, it is independent of language or country barriers, and hence, globally understandable.

Relationship between Indian and UNFC systems : In both systems, there are 8 standard terms used as follows.

Indian System	UNFC System
Proved in situ reserve	Measured resource
Proved recoverable reserve	Indicated resource
Probable in situ reserve	Inferred resource
Probable recoverable reserve	Proved reserve
Possible in situ reserve	Probable reserve
Possible recoverable reserve	Reconnaissance resource
Prospective resource	Prefeasibility resource
Conditional resource	Feasibility resource

But since the practical parameters are different, there is no simple one-to-one correspondence between the terms of the two systems.

Implementation of UNFC System in India

Decision making process : Both the Government and the mineral industry of India were represented in the Geneva Conference of the United Nations Economic Commission for Europe (UNECE) in November, 1999 where the decision for adoption and implementation of UNFC was finally taken after completion of a trial period. After that, the Government took a decision in principle to implement UNFC in India in view of the already started process of liberalising the Indian mining industry and opening it up to multinational investors for exploration and mining, for which India needed capital and technology. At the same time, it was considered necessary to project a relatively more realistic and objective picture of India's known mineral resource inventory. Further, in view of the prevailing system of a large number of geologists and mining engineers belonging to thousands of agencies independently engaged in resource estimation in India, it was thought that the broad exploration guidelines of UNFC may leave a wide scope of varying interpretation and that a set of practical field guidelines in quantitative terms needed to be standardised. So, in May, 2000 the Ministry of Mines (MOM), Government of India constituted a Task Force to formulate field guidelines for exploration as per UNFC, the report of which was submitted in August, 2000. For the purpose of these guidelines, mineral deposits were grouped into 7 types as follows.

1. Stratiform, stratabound and tabular deposits of regular habit
2. Stratiform, stratabound and tabular deposits of irregular habit
3. Lenticular bodies of all dimensions including bodies occurring en echelon, silicified linear zones of composite veins

4. Lenses, veins and pockets; stock-works, irregular shaped, modest to small size bodies
5. Gem stones and rare metal pegmatites, reefs and veins
6. Placer and residual mineral deposits of hill and valley wash
7. Dimension stones

Further, within the broad guidelines of UNFC, micro-level parameters were also identified for application in India. These parameters are:

- (a) Economic viability : Detailed geological knowledge, mining report/plan, specific end use grade reserves, forest/nonforest and other land-use data.
- (b) Feasibility study : Geological study including infrastructure, meteorology and ecology aspects; mining plans including issues pertaining to methods, recovery, manpower; environmental study including baseline data generation and impact analysis; beneficiation studies at laboratory, pilot plant and industrial scales; analysis of both capital and operational costs; analysis of needs of infrastructure, construction and services; marketing analysis covering demand-supply and industry structure; cashflow forecasts; issues related to labour, land, mining and taxation.
- (c) Geological exploration : Aerial reconnaissance by remote sensing and airborne geophysical survey; geological mapping; geochemical survey covering analysis of samples, geomorphology, drainage and vegetation; ground geophysical survey; pitting, trenching, drilling and sampling; petrographic and minerographic studies; rock mechanics studies (for dimension/building stones).

Depending on the type of mineral deposit, the quantum/level of work/analysis/study under these parameters the category of resource estimate may vary.

These Guidelines were thoroughly discussed during and after a seminar organised in Agra, India, under the aegis of UNECE, MOM and the Federation of Indian Mineral Industries (FIMI), and thereafter these were widely circulated to all the agencies concerned with resource estimation/evaluation — both in the Government and in the private sector. The final version of the Guidelines was submitted to the Government in February, 2001.

In May, 2001, the Government of India took the decision in favour of doing away with the Indian system of resource classification system and implementation of UNFC in India. After a prolonged consultation at different levels on the modalities of implementation, the decision was taken to the political level conference of the Central Government and all the State Government ministers of mines in January, 2003, wherein the final stamp of approval has been given. Thus the decision making process at all the 3 levels — technical, administrative and political — has been completed.

Strategy of implementation : The strategy of implementation as finalised by the Government of India mainly consisted in :

- (1) Conversion of the National Mineral Inventory database of IBM covering over 16000 deposits/leases/mines of 64 noncoal solid minerals, from Indian system to UNFC system.
- (2) Ensuring future resource estimation data generation as per UNFC through
 - (i) exploration according to the field guidelines as per UNFC, in both freehold and leasehold; and
 - (ii) amendment of the Mineral Conservation & Development Rules (MCDR) to make it statutorily obligatory for all noncoal major solid mineral mines to report to IBM, resource data classified as per UNFC system.

The noncoal solid mineral inventory database of IBM is presently as on 1-4-2000 incorporating the knowledge of all mineral deposits accrued till this point of time throughout the past, and it will be due for next updation as on 1-4-2005. Digging out old exploration reports and re-evaluating those data deposit by deposit or mine by mine would be an unpractical approach. So, a practical approach has been adopted. To begin with, a simple conversion table (Appendix-1) has been devised on the basis of experience of handling the data and after analysing their nature. The idea is that the present database should get converted on one time basis albeit not with 100% accuracy, but with successive updations based on progressive exploration in more and more of the already identified and documented deposits/mines, the accuracy will keep improving. It is expected that after a few updations, the accuracy will reach near perfection. In India there are many traditional small mines (e.g. bentonite, stones, clays etc.) where no geological exploration nor any feasibility nor prefeasibility study has ever been carried out, yet their economic viability is beyond doubt, since the mine owners are mining, selling and earning profit on their products. In such case "extended codes" of UNFC will apply (e.g. 133). The impact of the conversion to UNFC on the inventory as on 1-4-2000 has been studied for 4 minerals namely copper, lead-zinc, chromite and rock phosphate, which is shown in Appendix-2. It can be seen that large parts of hitherto reported "reserve" as per Indian system are now relegated to "resource" after implementation of UNFC system. So far as coal and lignite are concerned, the GSI has taken initiative for implementing UNFC.

Secondly, for ensuring future exploration as per UNFC guidelines in both freehold and leasehold areas, it has been planned that IBM would organise extensive training programmes on field guidelines at different centers across the country targeting geologists and mining engineers of

various Central and State Government organisations, and of the industries. Subsequently, GSI and some other organisations would also conduct their in-house training programmes in association with IBM.

Thirdly, for ensuring implementation of UNFC in noncoal major mineral leasehold areas, it has been decided by the Government to amend the Rules making it statutorily obligatory for all mineowners, to comply. They are required to report to IBM every month as well as annually, the information on the balance reserves available in their respective leases.

Conclusions

The whole process of decision making on adoption and implementation of UNFC in India has been through the period from November, 1999 to January, 2003. Summing up, the following points stand out prominently

- (1) India is a large, democratic and populous country with mineral resource data being generated continually at thousands of centers.
- (2) In the same deposit, more than one agency may explore at the same time or the same agency may explore at different times, with a possibility that resources may be estimated under different categories in different parts of the same deposit. The process is dynamic.
- (3) Mineral administration and legislative system in India is complex, with authorities vested on a large number of Central and State Government ministries and departments. There is also a multiplicity of laws for regulation of mining related activities.
- (4) Strategies for tackling past data contained in the national mineral inventory and for future exploration in freehold and leasehold areas have been formulated.
- (5) With a view to minimizing scope of variation in interpretation of the broad guidelines of UNFC by thousands of geologists and mining engineers independently generating resource estimation data, different sets of practical field guidelines in quantitative terms have been standardised for different types of mineral deposits.
- (6) For promoting practice of the new guidelines, a mixed approach consisting of extensive training and amendment of law has been adopted.
- (7) The entire process of implementation has been steadily and systematically institutionalised at all 3 levels — technical, administrative and political.

As in April, 2003, considerable progress has been achieved in case of noncoal nonatomic solid minerals. For coal and lignite also, initiative has already been taken. For petroleum, natural gas and atomic minerals, there is no report of progress, if any.

The impact of the changeover from Indian to UNFC system on the national mineral inventory is expected to be downward and very significant. This is expected to serve not only to project a more realistic picture of India's mineral resources, but also, in some cases, to rouse the planners from a sense of complacency. New thrust areas of exploration in already explored as well as virgin areas can now be planned on a sound basis; export and other mineral related policies can now be reframed on the basis of a more realistic knowledge base; and future exploration activities can now be streamlined.

Conversion table for national mineral inventory database

Status of estimation of resource	Category of resource as per Indian system	UNFC Code	Remark
A. Freehold deposit			
(i) Grade of reserve classified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	222 221 333	Equivalent of pre-feasibility study leading to classification of economic grade
(ii) Grade of reserve unclassified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	331 332 333	
(iii) Conditional resource with grade classified	Proved resource Probable resource Possible resource	331 332 333	
(iv) Conditional resource with grade unclassified	Proved resource Probable resource Possible resource	331 332 334	
B. Leasehold area			
(a) Working mines			
(i) Grade of reserve classified	Proved recoverable reserve Probable recoverable reserve Possible in situ reserve	111 122 333	Mineowner selling and earning profit
(ii) Grade of whole reserve unclassified	Proved recoverable reserve Probable recoverable reserve Possible in situ reserve	111 122 333	Mineowner selling and earning profit
(iii) Grade of part of reserve unclassified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	211 222 333	Mining may be in one part, but economic viability of remaining part uncertain.
(b) Temporarily idle mines			
(i) Grade of reserve classified	Proved recoverable reserve Probable recoverable reserve Possible in situ reserve	121 122 333	Mine owner already sold and earned profit.
(ii) Grade of whole reserve unclassified	Proved recoverable reserve Probable recoverable reserve Possible in situ reserve	121 122 333	-do-
(iii) Grade of part of reserve unclassified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	221 222 333	Mining might have been in one part, but economic viability of remaining part uncertain.
(c) Mining not commenced (i) Grade of resource classified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	221 222 333	Economic viability not yet proven through actual sale and profit.
(d) Conditional resource (i) Grade classified or unclassified	Proved in situ reserve Probable in situ reserve Possible in situ reserve	331 332 333	

Appendix-2

Impact of UNFC on National Mineral Inventory as on 1-4-2000

Reserve/Resource	Indian System		UNFC System		
	Category	Quantity	Code		Quantity
1. <u>Copper ore</u> Reserve	Proved, Probable & Possible	713 million tonnes	111, 122	121,	290 million tonnes
	Resource	722 million tonnes	221, 331, 333, 334	222, 332,	1049 million tonnes
2. <u>Lead-Zinc ore</u> Reserve	Proved, Probable & Possible	231 million tonnes	111, 122	121,	101 million tonnes
	Resource	280 million tonnes	221, 331, 333, 334	222, 332,	384 million tonnes
3. <u>Chromite</u> Reserve	Proved, Probable & Possible	114 million tonnes	111, 122	121,	47 million tonnes
	Resource	73 million tonnes	221, 331, 333, 334	222, 332,	132 million tonnes
4. <u>Rock phosphate</u> Reserve	Proved, Probable & Possible	193 billion tonnes	111, 122	121,	74 billion tonnes
	Resource	122 billion tonnes	221, 331, 333, 334	222, 332,	207 billion tonnes