INDIAN NATIONAL MINERAL RESOURCE CLASSIFICATION SYSTEM, ITS EVOLUTION AND MAPPING WITH UNFC 1997/2004

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INDIAN BUREAU OF MINES.
Introduction:

• Minerals have been in use since the earliest period of human civilization, Whatever produced was utilized.

• No need for any systematic exploration and inventory.

• Major changes in mineral consumption came about with the industrial revolution. Growth of industries was based on minerals and mineral products. The economy of most industrial countries became mineral dependent.

• Reserve and resource were often loosely used to signify quantities available in a deposit.

• Finer usage of these terms started after world war II. Newer & newer terms like resource, resource base, economic resource, prospect, etc proposed and came into existence.
Evolution of Mineral Resource Classification System - India

- In 1950s Mineral exploration in India received a thrust - discoveries of many mineral deposits in the 1960s.

- Motivated GSI to review the approach to mineral resource evaluation in the country.

- In 1970 GSI suggested a simpler classification system based on experience of resource estimation and needs of policy planners.

  i. Developed reserve, equivalent to ‘A’ category of USSR.
  ii. Proved reserve, equivalent to ‘B’ category of USSR.
  iii. Probable reserve, equivalent to ‘C1’ category of USSR.
  iv. Possible reserve, equivalent to ‘C2’ category of USSR.
  v. Potential reserves.

Weightage to estimation of tonnage & grade and retention of conventional terminologies.
In 1975, the National Council of Cement and Building Materials (erstwhile CRII) proposed a classification system for cement grade limestone which defined terminologies more precisely as mentioned below.

- **Inferred reserve**: The maximum error limit in quality of estimated reserve was 50% and that in CaO content 4%. The estimation was based on reconnaissance and regional prospecting.

- **Indicated reserve**: The maximum error limit in quantity was 30% and that of in the CaO 3%. This could be the basis for renewal of prospecting licence for detailed exploration/application for mining lease.

- **Measured reserve**: The maximum error limit in quantity of estimated reserves was 15% and CaO content 2%. This could be the basis for detailed project report and investment decision.

- **Developed reserve**: This is the blocked out quantity for mining.
The coal resource classification system was in place since 1956 and it was reviewed in 1979.

The ‘inferred’, ‘indicated’ and ‘proved’ terminology, in order of increasing geologic assurance, were in use.

Considering the mode of occurrence of coal seams, their nature and the trend towards increasing mechanization in the technology of their mining, the Committee on Standardisation of Terminology and Classification of Ore and Mineral (1981) constituted by the Government of India has recommended a different approach for estimation and classification of coal resources.

(Contd..)
• The degree of geologic assurance, in effect, a joint assurance of estimations of ash content, thickness and structure of coal seams.

• The criterion used in the classification of coal resource is the techno-economic parameters i.e. depth, seam thickness and ash, moisture and (in the case of the coal of north-eastern India only) sulphur contents. Both depth and thickness affect the techno-economics of mining, and the ash, moisture and sulphur contents influence the techno-economics of washability and ultimate utilization.

• On the basis of the criterion of degree of assurance of estimation of the three parameters, the resource has been classified into ‘assured’, ‘proved’, ‘probable’, ‘possible’, ‘prospective’ and ‘prognostic’ categories. The proved and probable reserves are together designated as ‘demonstrated reserve’. Part of the demonstrated reserve is ‘mineable reserve’.

• On the basis of the value of the techno-economic parameters, the probable and possible categories are classified into reserve and conditional resource, the latter may be para-marginal or sub-marginal.
Diagramatic representation of Coal Resource classification System (G.S.I. 1981)

<table>
<thead>
<tr>
<th>DEGREE OF ASSURANCE</th>
<th></th>
<th>PROSPECTIVE</th>
<th>PROGNOSTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSURED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROVED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROBABLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSSIBLE</td>
<td>MINEABLE RESERVE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUB-MARGINAL</td>
<td>PARA-MARGINAL</td>
<td></td>
</tr>
</tbody>
</table>

TECHNO-ECONOMIC FEASIBILITY
• The Indian Bureau of Mines started preparing and maintaining National Mineral Inventory in the country since 1970.


• No uniformity in terms used by exploration agencies.

• In 1979, Govt. of India constituted a committee to standardize (i) Uniform usage of terminologies for classification of ore reserves throughout India, (ii) Clear definition of terms and (iii) Quantification of parameters involved in the classification of ore reserves.

• In 1981, the committee has formulated its recommendations for standardisation of terminology, and also for mineral and coal resource classification system (GSI Misc. Publication No. 58, 1981) (Contd.. Diagram)
### Mining Phase

- **Detailed Exploration Phase**
  - **Identified Resources**

### Ore Reserves (Tonnage and Grade)

<table>
<thead>
<tr>
<th>Developed Ore</th>
<th>Undeveloped Ore</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Mining Reserves with Design, Dilution, &amp; Extraction Factor)</td>
<td>(Insitu Reserves)</td>
</tr>
</tbody>
</table>

- **Economic**
  - Fully Proved
  - Partly Proved
  - Probable

- **Sub-Economic**
  - Marginal
  - Sub-Marginal

### Undiscovered Resources (Tonnage)

- **Prospектив** (in Known Areas)
- **Prognostic** (in Unknown Areas)

Diagrammatic representation of the scheme suggested by GSI (1981)
According to the phase of exploration and development operation, the resource is first classified into:

a. **Undiscovered** and
b. **Identified** resources.

- The Undiscovered resource further divided into:
  - ‘Prognostic’ and
  - ‘Prospective’ resources.

- The Identified resource has been classified into:
  - ‘Developed ore’ and
  - ‘Undeveloped ore’

- The Developed ore may either be: i) **Fully Developed** or
  ii) **Partly Developed**.

- The Undeveloped ore may either be: i) **Demonstrated** or
  ii) **Possible**.

- The Demonstrated reserve is finally classified into: i) **Proved** and
  ii) **Probable categories**.
According to techno-economic viability, identified resource classified as ‘economic ore’ and sub-economic ‘conditional resource’.

- The economic ore reserve includes the developed ore resource, proved category resource and parts of probable and possible categories of resources.

- The other parts of probable & possible categories of resource are accounted for by conditional resource.

- The Conditional resource is further classified into ‘Para-marginal’ and ‘Sub-marginal’. (Definitions of various terminologies used in resource classification.)

- The basic concept same as those followed in USBM and USGS.

- The main feature of this classification system was that it linked the intensity of exploration with different classes of resource estimation. However, since the intensity of exploration depends on many factors i.e. type of deposit, geological complexity, etc., it was not possible to link the classes of resources of all minerals with the intensity of exploration by virtue of a single scheme.
Until before 1980, resources in the mineral inventory were classified under three categories namely Measured, Indicated, and Inferred. This was solely on the basis of geologic assurance.

- Indian Bureau of Mines keeping in mind the classification suggested by GSI in general, and the actual data received from various agencies on reserves/resources estimation and exploration in particular, made slight modification in the scheme suggested by GSI (MISC. Publication No.58, 1981) and adopted the following modified scheme in the National mineral Inventory during 1985.

<table>
<thead>
<tr>
<th>Economic Feasibility</th>
<th>Degree of Geologic Assurance</th>
<th>Identified or Discovered Mineral Resources</th>
<th>Undiscovered Mineral Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Proved</td>
<td>Probable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insitu Reserve (Or Reserve)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conditional Resources</td>
</tr>
</tbody>
</table>

Figure - 3: Diagramatic representation of modified scheme for Mineral Resource Classification for preparation of National Inventory of Minerals (GSI,1981).
National Mineral Resource Classification system vis. a vis. National Mineral Inventory

- The BIS with the help of the GSI and representatives of IBM and other organisations has revised the definitions of the terminologies for exploration of mineral deposits and also the norms of exploration. The diagramatic representation of BIS suggested mineral resource classification for preparation of national inventory of minerals is given in figure 4.

<table>
<thead>
<tr>
<th>RESOURCES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Currently Feasible &amp; Feasibility indicated in Future)</td>
<td>(Future)</td>
</tr>
<tr>
<td>Reserves Developed (Feasible)</td>
<td>Reserves Base (Futuristic)</td>
</tr>
<tr>
<td>(Blocked on 4 Sides)</td>
<td></td>
</tr>
<tr>
<td>Error 10% Max.</td>
<td></td>
</tr>
<tr>
<td>Proved (Intensive Exploration)</td>
<td></td>
</tr>
<tr>
<td>Error 10–20%</td>
<td></td>
</tr>
<tr>
<td>Probable (Less Intensive Exploration)</td>
<td></td>
</tr>
<tr>
<td>Error 20 – 30%</td>
<td></td>
</tr>
<tr>
<td>Possible (Geological Considerations)</td>
<td></td>
</tr>
<tr>
<td>Error 30 – 50%</td>
<td></td>
</tr>
<tr>
<td>CONDITIONAL RESOURCES (Feasible in Foreseeable Future)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. - 4 : Diagramatic representation of Bureau of Indian Standards (BIS) suggested Mineral Resource Classification for preparation of National Inventory of Minerals.
• Looking at the needs of the industry for mining planning and decision making, the concept of recoverable reserves introduced in NMI w.e.f. 01.04.1990.

• Indian resource classification system adopted in National Mineral Inventory as on 01.04.1990 onward till the year 2000 inventories is shown in the diagram.

Indian Resource Classification System adopted in National Mineral Inventory
## Indian System of Categorisation of Resources

**Increasing degree of geologic certainty**

<table>
<thead>
<tr>
<th>INSITU</th>
<th>RECOVERABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECONOMIC RESERVE</strong></td>
<td><strong>PROVED</strong></td>
</tr>
<tr>
<td><strong>CONDITIONAL RESOURCES</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Increasing Tech - economic viability**

- **INSITU**
- **RECOVERABLE**
- **ECONOMIC RESERVE**
- **CONDITIONAL RESOURCES**

- **PROVED**
- **PROBABLE**
- **POSSIBLE**
- **PROSPECTIVE**
- **PROGNOSTIC**
Indian System of Classification of Resources

- 2 dimensional system (geological & techno-economic) with emphasis on geological axis.

Geological parameters:
- Spacing of the observation points (boreholes, pits, trenches)
- Scale of geological mapping

Techno-economic parameters:
- Grade
- Amenability to beneficiation
- Thickness & depth (in case of coal)
- Some general considerations of environment, forest, market, etc.

- After a laborious, prolonged effort through individual interactions, conferences, trainings, system got firmly entrenched in Indian mindset.

(Click for Definition of terms used in classification)
Implementation of UNFC System in India

1. The decision

- January, 1993 - Indian law amended for opening up the mineral sector to globalization and privatization.

- November, 1999 - Decision on adoption of UNFC taken in Geneva Conference of UNECE.
  Government & Industry of India both were represented.

- May, 2000 - Government constituted Task Force to formulate field guidelines in quantitative terms as per UNFC,


- December, 2000 - Guidelines debated in a Seminar at Agra, India.

(Contd.)
Implementation of UNFC System in India

- December, 2000 to February, 2001: Further consultation with all Government agencies and industries of India on these guidelines.


- May, 2001: Government decides on a strategy for implementation of UNFC.

- May, 2001 to January, 2003: Further consultations and ensuring the workability of the strategy.

- January, 2003: The conference of Central & State Ministers of Mines gave final stamp of approval for adoption of UNFC and implementation of the strategy.
The Strategy

1. For already generated resource data

- National Mineral Inventory (NMI) as on 1.4.2000 prepared by Indian Bureau of Mines covering 64 non-coal, solid minerals has been codified as per the UNFC system.

- NMI database maintained by IBM was modified in collaboration with BRGM, France.

- Initiative by the GSI regarding coal & Lignite inventory.

(Contd..)
The Strategy

2. For future exploration & resource estimation:

- Amendments in MCDR were made to make it statutory for all non-coal major mineral mines to report to IBM their reserve data as per UNFC and also for ML applicants to submit mining plans accordingly.

- Also extensive training by IBM covering concerned Central and State Government agencies and industries & individuals.

  Number of programmes at different centres were conducted.

- In-house training by GSI, MECL and other agencies.
UNITED NATION FRAMEWORK CLASSIFICATION (UNFC)

• The main objective of this classification is to create an instrument that will permit reserves/resources of solid fuels and mineral commodities to be classified on an internationally uniform system based on market economy criteria.

• The system designed to allow incorporation of existing terms into it in order to make them comparable and compatible, thus enhancing international communication.

• The three digit code system directly reflects the procedure used in the practices to investigate and evaluate mineral reserves/resources and accommodates the results of these investigations and evaluations i.e. reserves/resources figure quoted in the respective reports and documents.

Contd..
UNFC is a system classifying the estimates based on three digit codes representing 3 axes, viz. Geological assessment (G), Feasibility assessment (F) and Economic viability (E).

Codes are represented as (EFG)
An overview of UNFC

- **Three codes for each economic and feasibility axis** i.e. 1, 2 and 3 (in order of decreasing economic viability and feasibility assessment, respectively).

- However, **four codes for geological axis** i.e. 1, 2, 3 and 4 (in decreasing order of geological certainty).
### An overview of UNFC

#### Stages/levels of E, F & G axis

<table>
<thead>
<tr>
<th>Code</th>
<th>Economic Axis</th>
<th>Feasibility Axis</th>
<th>Geological Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic</td>
<td>Feasibility Study &amp; Mining Report</td>
<td>Detailed Exploration</td>
</tr>
<tr>
<td>2</td>
<td>Potentially Economic</td>
<td>Pre-Feasibility Study</td>
<td>General Exploration</td>
</tr>
<tr>
<td>3</td>
<td>Intrinsically Economic</td>
<td>Geological Study</td>
<td>Prospecting</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>Reconnaissance</td>
</tr>
</tbody>
</table>

**Stages of G,F,E Axes**

The highest category of resource under UNFC System will have the code (111) and lowest category the code (334)
To classify reserves under UNFC in different confidence levels, specific norms of exploration have been fixed.

To classify reserves under UNFC, exploration details alone are not sufficient. In addition, feasibility assessment and economic viability should also be addressed.
• It is obvious that economic viability can not be addressed without feasibility assessment and feasibility assessments can not be done without exploration details. Thus exploration details of a deposit are basic and essential information.

• All the three attributes of the UNFC i.e economic viability, feasibility assessment and exploration details are interlinked and reserves and resources are defined under UNFC in combination of these three attributes.
An overview of UNFC
3D MODEL OF CODES
An overview of UNFC

- To classify reserves under UNFC, economic viability of the deposit plays major role.

- Estimates of deposits, which are economically viable, are classified as Reserves and remaining are placed under Resources.
An overview of UNFC

**UNFC CODES FOR VARIOUS CATEGORIES OF RESERVES/RESOURCES**

<table>
<thead>
<tr>
<th></th>
<th>Economically minable part of Resources</th>
<th>Proved Mineral Reserves</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>111</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable Mineral Reserves</td>
<td>121, 122</td>
</tr>
<tr>
<td>2</td>
<td>Feasibility Mineral Resource</td>
<td></td>
<td>211</td>
</tr>
<tr>
<td></td>
<td>Pre- Feasibility Mineral Resource</td>
<td></td>
<td>221, 222</td>
</tr>
<tr>
<td>3</td>
<td>Intrinsic economic interest, reasonal prospect for eventual economic extraction</td>
<td>Measured Mineral Resources</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indicated Mineral Resources</td>
<td>332</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inferred Mineral Resources</td>
<td>333</td>
</tr>
<tr>
<td>4</td>
<td>Reconnaissance Resource</td>
<td></td>
<td>334</td>
</tr>
</tbody>
</table>
To implement UNFC ...

Ministry of Mines, Govt. of India constituted a Committee to formulate field guidelines for mineral resource estimation in India.

The committee has identified seven types of mineral deposits with exploration norms.
Seven types of deposits are:

(i) Stratiform, Stratabound and Tabular Deposits of Regular Habit.

(ii) Stratiform, Stratabound and Tabular Deposits of Irregular Habit.

(iii) Lenticular Bodies of All Dimensions including Bodies Occurring enchelon, Silicified Linear Zones of Composite Veins.

(iv) Lenses, Veins and Pockets; Stock-works, Irregular Shaped Modest to Small size Bodies.

Contd...
(v) Gem-stones and Rare Metal Pegmatites, Reefs and Veins.

(vi) Placer and Residual Mineral Deposits of Hill and Valley Wash.

(vii) Dimension stones.

(Click for detailed Exploration Field guidelines)

Accordingly, field guidance was formulated for each type of deposit. Parameters/components considered for formulation of field guidance/to assign different level of codes for economic, feasibility and geological axis are basic requirement for classifying reserves under UNFC.
Summary of various attributes have to be addressed in Geology, Feasibility and Economic axes of UNFC.

<table>
<thead>
<tr>
<th>Economic Axis</th>
<th>Feasibility Axis</th>
<th>Geological Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information on</td>
<td>Geology</td>
<td>Aerial Survey</td>
</tr>
<tr>
<td>• Detailed Exploration</td>
<td>• Mining</td>
<td>• Geological study</td>
</tr>
<tr>
<td>• Mining Report</td>
<td>• Environment</td>
<td>• Geophysical study</td>
</tr>
<tr>
<td>• Marketing</td>
<td>• Mineral Beneficiation</td>
<td>• Geochemical study</td>
</tr>
<tr>
<td>• Knowledge about other attributes like forest etc.</td>
<td>• Infrastructure</td>
<td>• Technological study</td>
</tr>
<tr>
<td></td>
<td>• Costing</td>
<td>• Petrography/ mineralogical study</td>
</tr>
<tr>
<td></td>
<td>• Marketing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Economic viability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Other factors</td>
<td></td>
</tr>
</tbody>
</table>
Mapping of NMI with UNFC 1997 / 2004

Chromite deposits of National Mineral Inventory as on 01.04.2000 have been mapped with UNFC 1997/2004 to assess the practical applicability and impact of implementation to the mineral resources of NMI. The outcome of the same is as under (Click for deposit wise mapping).

Word
<table>
<thead>
<tr>
<th>Name of the Deposit</th>
<th>Lease status Working/Non-working</th>
<th>Type of Reserve/Resources</th>
<th>Reporting as per Indian System</th>
<th>United Nations Framework Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Proved</td>
<td></td>
</tr>
<tr>
<td>South Kaliapani</td>
<td>Public, Working, Non-Captive</td>
<td>Insitu</td>
<td>9776</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>543</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>10319</td>
<td>84</td>
</tr>
<tr>
<td>Karmarda</td>
<td>Private, Working, Non-captive</td>
<td>Insitu</td>
<td>47</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>-</td>
<td>460</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>47</td>
<td>600</td>
</tr>
<tr>
<td>Saruabil</td>
<td>Private, Working, Captive</td>
<td>Insitu</td>
<td>1880</td>
<td>980</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>941</td>
<td>2388</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>2821</td>
<td>3368</td>
</tr>
<tr>
<td>Sukarangi</td>
<td>Public, Non-captive</td>
<td>Insitu</td>
<td>3044</td>
<td>1379</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>-</td>
<td>2918</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>3044</td>
<td>4297</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>360</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>1135</td>
<td>0</td>
</tr>
<tr>
<td>Gurjhang Ostopol</td>
<td>Freehold</td>
<td>Insitu</td>
<td>170</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditional</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>170</td>
<td>286</td>
</tr>
</tbody>
</table>

All deposits belongs to Jajpur district except Bangur which is in Keonjhar district.
Conclusion:

At the national level IBM is the nodal agency which prepares and maintains National Mineral Inventory resource data base of non-coal and non-fuel solid minerals. Over the years resource classification in India has gone through various stages of evolution by way of adopting various geological and techno-economic criteria to resource classification to meet the requirements of the policy planners, decision making at government level for the development of mining industry in the country.

(Contd..)
The adoption of UNFC in the year 2000 was a historic moment for India in mining sector as the mineral resources could be codified as per UNFC system and presented its minerals resource on a universally accepted platform to the global investors. The UNFC system is an instrument that permit reserves/ resources of solid fuels and mineral commodities to be classified on an internationally uniform system based on market economy criteria. The three digits code system i.e. economic viability (E), field project status and feasibility (F), and geological knowledge (G) of the classification directly reflects the procedure used in the practices to investigate and evaluate mineral reserves/resources.
Thanks