STAGES OF EXPLORATION

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1. Reconnaissance Surveys (G4 stage)
2. Preliminary Exploration (G3 stage)
3. General Exploration (G2 stage)
4. Detailed Exploration (G1 stage)

1. Reconnaissance Surveys (G4 stage)

The main purpose is to reduce the areas by identifying select ones for further studies.

- **Systematic geological mapping on 1:50,000 scale.**
- **Airborne Geophysical Surveys (Magnetic, Electro-magnetic & Radiometric).**
- **Regional geochemical sampling (wide spaced).**
- **Regional geophysical survey (wide spaced).**
- **Photo-geological and Remote sensing studies (PGRS).**

2. Preliminary Exploration (G3 stage)

Generally conducted for smaller areas, a few kms. to tens of Sq.kms.

- **Geological mapping on 1:25,000 or 1:10,000 scale.**
- **Geochemical grids and ground geophysical grids for prospecting are kept at a closer intervals for the precise selection of the target areas.**
- **Pitting and trenching carried out to expose the ore body if near to the surface.**

3. General Exploration (G2 stage)

Work is conducted over very small areas (less than a Sq.km to a few Sq.kms).

- **Detailed mapping on 1:5,000 or 1:4,000 scale.**
- **Pitting, trenching and bed rock sampling on all out-crop sections.**
- **Drilling on systematic pattern upto 60 to 120m depth and at 100m strike interval for gold, 200m for base-metals and 400m - 500m for limestone.**
- **Detailed petrological and mineral studies.**
- **Within the mineral deposit economically viable zones, their strike length, width and depth identified based on surface studies and drilling data.**
- **Ore reserves estimated.**

4. Detailed Exploration (E-II stage)

- Exploratory openings or boreholes are drilled at closer intervals along the strike and also depth wise, to accurately determine the shape, size, disposition of ore and grade of ore body.
- Detailed mapping on 1:2,000 or 1:1,000 scale.
- Mineral phases (by EPMA), beneficiation test carried out.
- Processing of all databases.
- Ore reserves estimated.

- **May 2001: MoM, Govt. of India approved the UNFC and the field guidelines for implementation.**
- **The UNFC scheme consists of three dimensional system with the following three axis:**

a. The stages of Geological Assessment (G)

b. **The Stages of Mineability Assessment (Feasibility or F)**

c. The degree of Economic Viability (E)

UNFC three digit code system

- **Economic viability axis represents the first digit, the feasibility axis the second digit and the geologic axis the third digit.**

- **Economic viability has three codes which in decreasing order are:- E1 (Economic), E2 (Potentially economic) and E3 (intrinsically economic).**

- **Feasibility study has three codes which in decreasing order are:- F1 (Feasibility study), F2 (Pre-feasibility study) and F3 (geological study).**

STAGES OF EXPLORATION AS PER UNFC NORMS

The geological assessment (G) as per UNFC norms has four codes in order of increasing details.

(i) **Reconnaissance (G4)**

(ii) **Prospecting (G3)**

(iii) **General Exploration (G2)**

(iv) **Detailed Exploration (G1)**

Each stage generate resource data with a clearly defined degrees of geological assurance.

G4 (Reconnaissance)

1. Aerial Reconnaissance: Remote sensing, airborne geophysical etc.
2. Geological survey: Mapping on 1:50,000 or 1:25000 scale.
3. Geochemical Survey: i) Grab, chip sampling (ii) Recording of broad geomorphology, drainage etc.
4. Geophysical Survey: Ground Geophysical survey.
5. Technological: i) Pitting/Trenching: one or two to expose mineralized zone at ideal location ii) Scout drilling: A few boreholes to know the existence of mineral iii) Sampling: Regional and random chip samples.
6. Petrographic and mineralogical studies: To determine principal rock types, mineral assemblage, identification of mineral of interest.
7. Synthesis of all available data / concepts.

G3 (Prospecting)

1. Geological Surveys: i) Mapping on 1:10,000 or larger scale ii) Linking of prepared maps with topogrid iii) Assessment of lithology, structure, surface mineralization, analysis of old workings etc.
2. Geochemical Survey: Geochemical sampling rock type wise, soil survey.
3. Geophysical Survey: Detailed ground geophysical work, borehole logging.
4. Technological: i) Pitting/trenching to explore mineralized zone ii) Drilling borehole spacing: a. coal, gypsum, potash, salt beds 1000 to 2000m, b. limestone/dolomite 400 to 500m, c. Iron and manganese 200 to 400m, d. Bauxite 300 to 400m, e. chromite 300m, f. barite 500m, g. base metals 200m and h. gold 100m.
5. Sampling: litho geochemical from a well known section, pit/trench and core sampling.
6. Petrographic and mineralogical studies: study of host rock of the deposits and alteration zone, determination of phase in which minerals occur and mineralogical studies (ore microscopic, XRD, EPMA etc), identification of oxidized and primary zones.

G2 (General Exploration)

1. Geological Survey: Mapping on 1:5000 or larger scale with triangulation points, linking of prepared maps with topogrid and assessment of lithology, structure, mineralization.
2. Geochemical Survey: i) detailed litho geochemical survey, channel sampling from fresh mineralized rocks exposed by trenching/pitting, ii) recording of deleterious elements and by product elements.
3. Geophysical survey: i) Borehole geophysical survey ii) special survey for problem solving.
4. Technological : i) Systematic pitting / trenching, ii) Drilling Borehole spacing a. coal/gypsum/rock salt 400 to 1000m, b. iron and manganese 100 to 200m, c. limestone/dolomite/barite 200 to 400m, d. bauxite / chromite 100 to 300m, e. basemetals 100m and f. gold 50m, iii) Sampling: Systematic pit/trench and core sampling iv) Bulk sampling, if necessary v) collection of geoenvironmental parameters.
5. Petrographic studies.
6. Beneficiation test .

RESERVE ESTIMATION

Depending on certain parameters:

- Cut off grade
- Stopping width
- Weighted average and average grade
- Tonnage factor
- Core recovery
- Thickness
- Strike length/ strike influence
- Dip length/ width influence
- Correlation of lode

RESERVE ESTIMATION METHODS

For moderately to steeply dipping tabular ore body

- Cross section method
- Longitudinal section method
- Level plan method

For bedded/ horizontal or low dipping deposits

- Included area method
- Extended area method
- Triangle method
- Polygon method
- Method of isoline
- Isopach maps method

CLASSIFICATION & CATEGORISATION OF RESERVES

In India, GSI standardized the terminology of ores & Mineral resource Classification.

- In practice in India since 1981.
- Later standardized by Bureau of Indian standards (BIS) in 1989.
- **This system was followed in the (National Mineral Inventory) NMI database created by IBM.**

Type of Reserve

- **Developed**
- **Proved**
- **Probable**
- **Possible**

PROBABLE RESERVE

A. Estimates made on the basis of measurements from widely spaced sampling points and exploratory openings(borehole/ pit/ trenches) with reasonable extrapolation on geological grounds.

B. The shape, thickness variation, likely persistence, geological structure are broadly known. Some information on mineralogy, petrography of the host rock and wall rocks, ore dressing characteristics.

C. The error of estimation of tonnage should be in the range of 20-30 %.

D. This category implies a clearly lower status to the ore reserve in terms of degree of assurance, in spite of being still within the direction of economic considerations.

Possible Reserve

The Possible Reserve have the following characteristics:-

A. The grade estimate of a possible reserve is a broad indication of the likely quality.

B. The possible reserve contains only very general information on the mode of occurrence of geological structure and ore behavior.

C. The 'Possible Reserve' may have an error level of 30 to 50 %.

COMPARISON OF CONVENTIONAL INTERNATIONAL AND NATIONAL CLASSIFICATION SYSTEM (1980)

U.S.G.S/ U.S.B.M CLASSIFICATION			U.S.S.R CLASSIFICATION			NATIONAL CLASSIFICATION		
Category	**Purpose**	**Permissi. Error**	**Category**	**Pourpose**	**Permissi. Error**	**Category**	**Purpose**	**Permissible Error**
			A	Production planning Mine protection	15-20 %	Developed	Production planning and ready for mining	0-10 %
Measured		0-20 %	B	Estimating mining investment and planning of development of the deposit.	20-30 %	Proved	Investment decision mine planning	10-20 %
Indicated		20-40%	C_1	Long term development plans for projecting exploration needs.	30-60 %	Probable	Backup tonnage to proved reserves for investment decision for mine development/ likely geological reserve to decide on detailed exploration	20-30 %
Inferred	Planning for further exploration		C_2	Planning further prospecting	60-90 %	Possible	First quantitative approximation for planning for national resources survey	30-50 %

MINERAL RESOURCE (GEOLOGICAL AXIS)

- **Reconnaissance Mineral Resource (334):** Estimate based on preliminary field inspections, regional geological studies and mapping.
- **Inferred Mineral Resource (333):** Inferred from geological evidence. Tonnage, grade and mineral content can be estimated with low level of confidence.
- **Indicated Mineral Resource (332):** Tonnage, shape, grade and mineral content can be estimated with reasonable level of confidence. Location of boreholes, pits etc are too widely spaced.
- **Measured Mineral Resource (331):** that part of mineral resource for which tonnage, density, shape, grade and mineral content can be estimated with a high level of confidence i.e. based on detailed exploration.

CORRELABILITY OF UNFC AND NATIONAL CLASSIFICATION

UNFC	Category & Code	NMI Category	
Mineral Reserve	Proved 111	Proved	Recoverable Mineral Reserve
	Probable 121, 122	Probable	do
Mineral Resource	Measured 331	Proved	In situ Mineral Resource
	Indicated 332	Probable	do
	Inferred 333	Possible	Recoverable Mineral Resource
	Feasibility 211 Mineral Resource	Proved	Conditional in situ Resource
	Pre Feasibility 221, 222	Probable	do
Reconnaissance Mineral Resource	Mineral Resource 334		Prospective Mineral resource