

DIFFERENT STAGES AND PRACTICES OF GEOLOGICAL PROSPECTING, REGIONAL AND DETAILED EXPLORATION.

Any exploration program can be classified by successive stages: each stage is designed to achieve a combined specific objective within the time schedule and allocated fund. The outputs of each stage provide inputs to the next successive stage. The stages for major and limited application for minor minerals are placed in ascending order with respect to increasing geological confidence in the context of any exploratory procedure.

The typical successive stages of geological investigation i.e. *reconnaissance, prospecting, general exploration and detailed exploration*, generate resource data with clearly defined degrees of geological assurance.

Reconnaissance (G4)

Reconnaissance is a grassroots exploration for identifying the existence of mineral potential or initial targets on a regional scale. Preparations at this stage include literature survey, acquisition of geophysical data, if any, synthesis of all available data and concepts, and obtaining permission (reconnaissance license/permit [RP]) from the state/ provincial/territorial government.

Activities incorporate remote sensing, airborne and ground geophysical survey, regional geological overview, map checking/mapping on 1:250,000 and 1:50,000 scales, geochemical survey by chip/grab sampling of rocks and weathered profiles, broad geomorphology and drainage, pitting, and trenching to expose mineralized zones at ideal locations, and limited scouting/reverse circulation/diamond drilling to identify the possible existence/extent of mineralization. Petrographic and mineragraphic studies will help to determine principal host and country rocks and mineral assemblages.

The prime objective is to study the entire area under leasehold within a stipulated timeframe, and to identify probable mineralized areas (targets) worthy of further investigation. The targets are ranked based on geological evidence suggestive of further investigation toward deposit identification. Subsequent activities are planned and suitably modified based on the results achieved. The definite physical targets of various exploration activities would depend on the end result.

Prospecting (G3)

Prospecting is the systematic process of searching promising mineral targets identified during reconnaissance. The objective is to increase definitive exploration for developing geological confidence leading to further exploration. The program starts by obtaining a prospecting license (PL) from the state/provincial/territorial government within the framework of area and duration. PL is granted to conduct prospecting, general exploration, and detailed exploration.

Activities include mapping on a 1:50,000-1:25,000 scale, linking maps with a Universal Transversal Mercator (UTM), lithology, structure, surface signature, analysis of history of mining, if it exists, ground geophysics, geochemical orientation survey, sampling of rock/soil/debris of background and anomaly area, pitting/trenching, reverse circulation and diamond drilling at a 100-1000 m section at one level depending on mineral type, core sampling, petrographic and mineragraphic studies, borehole

geophysical logging, and baseline environment. Estimates of quantities are inferred, based on the interpretation of geological, geophysical, and geochemical results.

General Exploration (G2)

General exploration is the initial delineation of an identified deposit. Methods include mapping on a 1:25,000, 1:5000, or larger scale for narrowing down the drill interval along the strike (100-400 m) and depth (50-100 m), detailed sampling and analysis of primary and secondary commodities, value-added trace and deleterious penalty elements, ~10% check sampling, analysis for quality assurance/quality control, borehole geophysical survey, bulk sampling for laboratory and bench-scale beneficiation tests, and recoveries and collection of geoenvironmental baseline parameters.

The objective is to establish the major geological features of a deposit, giving a reasonable indication of continuity, and providing an estimate of size with high precision, shape, structure, and grade. The estimates are in the Indicated and Inferred categories. The activity ends with preparation of broad order of economic or prefeasibility or scoping studies.

Detailed Exploration (G1)

Detailed exploration is conducted before the start of the mining phase or mine development. It involves three dimensional delineation to outline firm contacts of the ore body, rock quality designation (RQD) for mine stability, and planning and preparation of samples for pilot plant metallurgical test work.

The works envisaged are mapping at 1:5000 and 1:1000 scales, close space diamond drilling (100x50, 50x50 m), borehole geophysics, a trial pit in case of surface mining, and subsurface entry with mine development at one or more levels in case of underground mining. The sample data are adequate for conducting three dimensional geostatistical ore body modeling employing in-house or commercial software for making due diligence reports. The reserves are categorized as Developed, Measured, Indicated, and Inferred with a high degree of accuracy. The sum total of Developed, Measured, and Indicated reserves amounts to 60% of the total estimated resources for investment decisions and preparation of a bankable feasibility study report.

A mining lease (ML) is obtained at this stage for the purpose of undertaking mining operations in accordance with the Miners and Minerals (Development and Regulation) Act 2016 for major minerals. It shall also include quarrying concessions permitting the mining of minor minerals. The ML is granted by a competent authority, i.e., the state/provincial/territorial government, with clearance from the Federal Ministry of Mines, the Ministry of Forest and Environment, and the Bureau of Mines. The permissible area under the ML will be negligible and may be 1/100th of the reconnaissance area.

Feasibility Study

A decision whether to conduct a Feasibility Study can be made from the information provided by Detailed Exploration. Feasibility assessment studies form an essential part of the process of assessing a mining project. The typical successive stages of feasibility assessment i.e. geological study as initial stage followed by prefeasibility study and feasibility study/mining report are well defined.

Economic viability

The degree of economic viability (economic or sub-economic) is assessed in the course of prefeasibility and feasibility studies. A prefeasibility study provides a preliminary assessment with a lower level of accuracy than that of a feasibility study, by which economic viability is assessed in detail.

SUMMARY

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
 - 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.*

G1 (Detailed exploration)

1. *Geological Survey:*
 - i) Mapping – for coal 1:5000 and for others 1:1000
 - ii) Preparation of detailed topographic cum geological map incorporating lithology, structure, mineralized zones,pits/trench and boreholes etc.
 - iii) Topogrid / triangulation station , identified fiducially linking in the map
2. *Geochemical survey:* Detailed grid pattern sampling and analysis
3. *Geophysical Survey:* Detailed and specific borehole geophysical survey
4. *Technological:*
 - i) Pitting 2 to 5 per sq km
 - ii) Trenching at 200 to 300m spacing
 - iii) Drilling closer spaced
 - a. coal 12 to 15 borehole per sq km
 - b. for open cast project grid spacing may be 100x50m
 - iv) Exploratory mining
 - v) Sampling of pit/trench/core
5. *Petrographic and mineralogical studies*
6. *Geostatistical studies*

Feasibility Study
Economic viability