Welcome To Presentation on MINERAL EXPLORATION PRINCIPLES AND TECHNIQUES

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Mineral Exploration Corporation Limited
MECL's Presence

Since inception across pan India catering to Mineral & Mining Segments

Exploration Value Chain

Creating mineral wealth for India from resources to reserves

Current Operations

Leadership position in NMET through expertise in complete value chain

Journey Continues

Credentials to pursue capacity building and capability augmentation
Significant Achievements

Since inception, MECL has strived to undertake detailed mineral exploration and create mineral wealth for the nation as the only integrated exploration entity pursuing the initiative along with GSI’s regional scale mapping for minerals.

**Bauxite**
- Panchpatmali Bauxite Deposit - NALCO
- Baphlimali Bauxite Deposit - OMC

**Copper, Lead & Zinc**
- Malanjkhand Copper Deposit – HCL
- Kayar Lead Zinc Deposit – HZL/ Vedanta

**Gold**
- Chigargunta Gold Deposit – BGML
- Hutti Gold Deposit - HGML

**Iron**
- Chiria Iron Ore Deposit - SAIL

**Coal & Lignite**
- Resource Accretion of Coal – Coal India Ltd.
- Lignite – NLC India Ltd.

**Geological Report**
- 1452 Nos.

**Mineral Resource**
- 163 Billion Tonnes
Pan India Presence

MINERAL MAP OF INDIA

- 17 Blocks
  - Iron Ore - 7
  - Manganese - 8
  - Copper - 1
  - Mn & Iron - 1

Odisha

- 5 Blocks
  - Iron - 1
  - Copper & Gold - 2
  - Tin - 1

Jharkhand

- 9 Blocks
  - Bauxite - 4
  - Limestone - 4
  - Coal - 1

Chhattisgarh

- 13 Blocks
  - Copper/Gold/Base metal - 9
  - Iron - 1
  - Limestone & Potash - 2

Rajasthan

- 9 Blocks
  - Limestone - 7
  - Graphite + PGE + Mn - 1
  - Gold & Base

Madhya Pradesh

- 6 Block
  - Gold + Nickel + Cobalt + Lead Zinc - 2
  - Limestone - 2

Karnataka

- 4 Blocks
  - Magnesite / Dunite - 2
  - Lignite - 2

Tamilnadu

- 22 Blocks
  - Phosphorite - 1

Uttar Pradesh

- 4 Blocks
  - Coal - 1
  - Limestone - 3

Telangana

- 6 Blocks
  - Mn - 2
  - Tungsten - 1
  - PGE - 2
  - Multi Metal - 1

Maharashtra

- To Start

INDEX

- Coal / Lignite
- Iron
- Bauxite
- Manganese
- Copper
- Gold
- PGE
- Lead & Zinc
- Salt(K) Potash
- Limestone
- Dunite

SOURCE: GEOLOGICAL SURVEY OF INDIA
Vision & Mission

Carved out of GSI in 1972, MECL is a Mini Ratna I CPSE under Administrative control of Ministry of Mines, Government of India.

Primarily engaged in detailed exploration of potential mineral deposits leading to auctionable mineral acreages for state governments and creation of mineral wealth for the nation.

A niche and knowledge driven zero debt company with authorized capital of Rs. 125.00 Crores and man power strength of about 1000.

MECL’s “Vision 2030” is under preparation for pursuing the growth strategy and select diversification initiatives.

To be the leader in exploration of minerals by 2020 in the country

To provide high quality, cost effective and time bound geo-scientific services for exploration and exploitation of minerals.
Exploration Campaigns

Exploration Campaigns are carried out under two verticals & projects are executed as

Promotional Exploration for major, minor, critical and strategic minerals and energy minerals are carried out on behalf of and funded by NMET / Govt. of India.

Contractual Exploration on behalf of State Governments, Public Sectors and Private Sector entities on mutually agreed terms and conditions.
Diversified Flagship Projects

20 Auctioned Blocks – MMDRA 2015:
• Diamond – 01 no. in Madhya Pradesh
• Gold – 04 nos. in Jharkhand
• Gold – 01 no. in Andhra Pradesh
• Iron – 14 nos. in Karnataka

- Creation of Integrated Lignite Resources Information System for NLC
- Ore Body Modeling of Karlapat Bauxite Deposit, Odisha
- Deepest borehole of 1400m+ in CBM exploration, Jharia Coal Field.
- Drilling for sand plugging in Jharia Coal Field to control Coal Mine Fire
- Drilling up to 1000 m (3 nos.) in bedded salt for solution mining for salt cavern storage
- Diamond Exploration in Hatupur, MP & Kalyandurg in AP

- Resource estimation of Oil Shale in Assam & Arunachal Pradesh on behalf of DGH.
- Ground water potential maps under “Rajiv Gandhi National Drinking Water Mission”
- Drilling for geo-thermal investigation in Laddakh
- Site characterization for nuclear waste repository for BARC
- Geo-technical studies at Pir Panjal range of Jammu & Kashmir
- Mid stream drilling in high velocity water flow of Dihang, Arunachal Pradesh on behalf of Brahmaputra Flood Control Commission.
Exploration Value chain

- Statutory Forest Clearances
- Interface with District Authorities
- Crop Compensations
- Extensive Study and Assessment for identification of Mineral exploration acreages
- Geological Mapping
- Topographic (DGPS) Survey
- Sampling-trenching & pitting
- Surface Geophysical Investigation
- Borehole Geophysical Logging
- Geological Core Logging
- Identification of Mineralization Zone
- Core Sampling
- Preparations of Geological Reports
- Maps, Cross Sections, Ore body Disposition
- Delineated Mineral Acreages with estimated reserve of mineral wealth for Auction / Asset

Integrated Exploration Campaign for Mineral Acreages
Fleet of Drilling Rigs with productivity

- **Conventional Drill Rigs**
  - 41 nos.
  - Depth up to 300m to 1000m

- **Hydrostatic Drill Rigs**
  - 34 nos.
  - Depth up to 600m to 2000m

- **Special Type Drill Rigs**
  - 12 nos.
  - Depth up to 40m to 750m

**Drill Rigs**
- 87 nos.
Central Manufacturing Centre (CMC)

WE MAKE

TC BIT

Core Barrels – NQ & HQ

Drilling Accessories

Tubulars - Drill Rod Casings

Spare for Drills & Pumps

OUR STRENGTHS

✓ We meet 100% of TC Bits requirements

✓ 20% drilling is done by TC Bits

✓ Cost and Performance Efficiency
  Cost of In-house manufactured Core-Barrel works out to be about Rs. 18,000/- to 20,000/- per unit as against Imported Core-Barrels costing Rs. 2,50,000/- per unit.
Geophysical Expertise

Geophysical Equipments with MECL

Available

- Bore Hole Logging Unit: 8
- Gravity Meters: 2
- Magneto Meters: 2
- Resistivity/S.O./LP: 1

Under Procurement

- Resistivity Imaging System: 8
- Electromagnetic Logger Unit: 2

Up-gradation plan

- Seismic 2D/3D: 1
- Gravity Meters: 2
- Injection fall of tests: 2
- Induction Polarization: 1
ISO-1702 NABL Accredited
Coal/ Lignite Testing
Non Coal Mineral Sample Testing
Drilling Fluid Mud Testing
Mechanised sample preparation
AAS and XRF

Transmitted Light
Petrographic Study
Reflected Light Petrographic Study
Thin Petrographic Section Cutting
Thin Section Polishing

Modernization of Laboratory Building & Equipments
Covering all activities under NABL Accreditation
Enhancing capacity of Lab to 1.50 lakh samples per year in next 03 year
Software Packages

**Exploration and Mining**
- GDM, BRGM (France)
- Minex
- SURPAC

**Map Production and GIS Application**
- AutoCAD Map Suit – 2016
- Autodesk (USA)

**Other Software**
- RDBMS Oracle 10g & 12c
- Visual Studio 6.0

**Remote Sensing**
- Geomatica
- ERDAS

Expertise

- Exploration Data Processing & Preparation of Interpretative Maps
- 3D Ore Body Modelling & Reserves Estimations
- Geostatistical Analysis for Sensitivity Study
- Geographic Information System and GUI tools
- Remote Sensing Application through satellite imageries
Geological Report Preparation

Stages in GR Preparation

Block wise Database Creation, Validation and Visualisation

Preparation and Statistics generation using In-house developed Software

Minex / SURPAC / GDM
3D Model, Fault Model, X & LV Sections, Geo Statistical Studies, Seam Folio, Contours
Achievements in Mineral Exploration

Total Resources Established 170 Billion Tonnes on March, 2019

- Coal: 74%
- Lignite: 19%
- Strategic & Precious Metal: 1%
- Ferrous & Non-Ferrous mineral: 3%
- Industrial minerals: 3%
ORES

- Rocks and minerals that can be recovered at a profit.

- Metals and metal bearing minerals

- Not all minerals containing a given elements are ore mineral- Fe silicate (fayalite) is not ore but magnetite and hematite are.

- An ore may be rock containing veinlets, dissemination or small amounts of useful mineral.

- Widely distributed, but are concentrated in amounts sufficient to be of economic value in the accessible part of Earth’s crust, and in a form that permits their recovery profitably.
Range of concentration factors that characterise the formation of ore deposits.

Some of the strategically important metals such as Fe, Al, Mg, Ti, Mn are abundantly distributed in the crust (0.5-10%) and needs only relatively small amount of enrichment inorder to make a viable deposit.

Fe and Al need concentration level of 9 and 4 respectively to make a viable deposit.
In contrast Basemetal (Cu, Pb, Zn, Ni) needs concentration by factors in 100s inorder to form potentially viable deposits.

For precious metals the level of enrichment goes upto 1000 times for making it a deposit.
Table 1  Average crustal abundances for selected metals and typical concentration factors that need to be achieved in order to produce a viable ore deposit

<table>
<thead>
<tr>
<th></th>
<th>Average crustal abundance</th>
<th>Typical exploitable grade</th>
<th>Approximate concentration factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>8.2%</td>
<td>30%</td>
<td>×4</td>
</tr>
<tr>
<td>Fe</td>
<td>5.6%</td>
<td>50%</td>
<td>×9</td>
</tr>
<tr>
<td>Cu</td>
<td>55 ppm</td>
<td>1%</td>
<td>×180</td>
</tr>
<tr>
<td>Ni</td>
<td>75 ppm</td>
<td>1%</td>
<td>×130</td>
</tr>
<tr>
<td>Zn</td>
<td>70 ppm</td>
<td>5%</td>
<td>×700</td>
</tr>
<tr>
<td>Sn</td>
<td>2 ppm</td>
<td>0.5%</td>
<td>×2500</td>
</tr>
<tr>
<td>Au</td>
<td>4 ppb</td>
<td>5 g t⁻¹</td>
<td>×1250</td>
</tr>
<tr>
<td>Pt</td>
<td>5 ppb</td>
<td>5 g t⁻¹</td>
<td>×1000</td>
</tr>
</tbody>
</table>

Note: 1 ppm is the same as 1 g t⁻¹.
Figure 2  Plot of crustal abundances against global production for a number of metal commodities (after Einaudi, 2000). The line through Fe can be regarded as a datum against which the rates of production of the other metals can be compared in the context of crustal abundances.
Some General Terminologies

- **Ore**: any naturally occurring material from which a mineral or aggregate of value can be extracted at a profit. The concept extends to coal (a combustible rock comprising more than 50% by weight carbonaceous material) and petroleum (naturally occurring hydrocarbon in gaseous, liquid, or solid state).
- **Syngenetic**: refers to ore deposits that form at the same time as their host rocks. In this book this includes deposits that form during the early stages of sediment diagenesis.
- **Epigenetic**: refers to ore deposits that form after their host rocks.
- **Hypogene**: refers to mineralization caused by ascending hydrothermal solutions.
- **Supergene**: refers to mineralization caused by descending solutions. Generally refers to the enrichment processes accompanying the weathering and oxidation of sulfide and oxide ores at or near the surface.
- **Metallogeny**: the study of the genesis of mineral deposits, with emphasis on their relationships in space and time to geological features of the Earth’s crust.
- **Metallogenic Epoch**: a unit of geologic time favorable for the deposition of ores or characterized by a particular assemblage of deposit types.
- **Metallogenic Province**: a region characterized by a particular assemblage of mineral deposit types.
- **Epithermal**: hydrothermal ore deposits formed at shallow depths (less than 1500 meters) and fairly low temperatures (50–200 °C).
- **Mesothermal**: hydrothermal ore deposits formed at intermediate depths (1500–4500 meters) and temperatures (200–400 °C).
- **Hypothermal**: hydrothermal ore deposits formed at substantial depths (greater than 4500 meters) and elevated temperatures (400–600 °C).
STAGES OF EXPLORATION

- As on today we have explored all surface indications of mineralisation including old workings.

- The task of modern exploration is aimed to locate hidden or concealed deposits.

- It is a multifarious activity that applies all known geological, geophysical, geochemical and remote sensing techniques in delineating target areas for detailed exploration involving various stages adopted in a sequential mode.
Stages.....

1. Reconnaissance
2. Prospecting
3. Exploration
4. Evaluation
The exploration strategy is more evolved than in the past.

It is resorted to multidisciplinary approach.

Exploration companies launch all exploration tools in sequential mode.

Needs a lot of background preparation like collation of previous data on geological, geophysical, geochemical, creation of GIS data base.

Launching all scales of work from Regional geology, geochemistry, and airborne geophysics.

The primary objective of the RE to delineate prospecting targets.
REGIONAL GEOLOGICAL SETUP.

✓ Procurement of Regional Geological Maps. Regional maps provide vital inputs in deciding the type of mineral commodity that can be explored in a given terrain.

✓ Provides information on distribution pattern of geological units useful for RE. Also shows mineral occurrences in the area.

✓ A good regional map gives a fair idea about litho sequences that eventually help in understanding the type of ore deposits that can be expected from it.
Information on abandoned mine is sought at this stage to strengthen geological understanding of the nature of mineralisation.

Thus the area to be applied for RE Permit or popularly known as RP is decided on the basis of Regional geology and the structure of the prospective tract.
AERO GEOPHYSICAL SURVEYS.

- Very effective in fast reconnaissance of large area and inaccessible terrains.
- Aero magnetic surveys can be done at higher altitudes.
- For EM signatures aircraft is maintained below 120m.
- Heliborne System can provide data from close to ground.
- The aero magnetic data can be used for mapping structures favorable for ore localization. Airborne EM surveys and magnetic surveys can be useful in identifying regional shear zones and fault zones.
- The aircraft of GSI has onboard systems that can generate data on EM, Total (γ-ray) count, U, Th, K, and aeromagnetics— as a routine 6 maps are produced.
Application of Remote Sensing Techniques:

- Remote sensing includes various mapping techniques that are carried out from airborne systems.
- Such techniques have received great deal of attention especially in connection with space exploration projects. The sensors are fitted either to a aircraft or to a spacecraft.
- However it is mainly the aerial photography and imaging systems that are useful in Reconnaissance Exploration.
- Aerial photo interpretation with limited field checks are popular techniques used advantageously even today.
- Satellite photos and imageries taken from spacecrafts are useful in broadly defining favourable areas of mineralisation.
HYPERSPECTRAL DATA

✩ Hyper spectral data are currently in great demand by various mineral exploration agencies and has a prime role in RE Stage.

✩ Very helpful in inferring chemical variations in zones of hydrothermal alteration.

✩ Hyperspectral data are not readily available to exploration agencies and their interpretation needs refinement.
The National Surveys and State organizations publish Regional maps of 1:250,000 or on 1:1 million scales.

These maps may not contain specific data required by an exploration agency.

50000 and 25000 scale maps of GSI are helpful in this regard.

The large scale mapping of an area is done with specific objective and are supposed to generate additional details on lithology, structure, metallogenic aspects etc. There may be some geochemical inputs also here.
The mineral exploration in the modern day is mainly aimed to locate hidden deposits sub-outcropping beneath thin soil or truly deeply buried.

Geochemical and geophysical surveys are reasonably successful in this type of studies.

Multi element approach has wider range of applications and offers new opportunities at the regional exploration stage for exhaustively filtering out and collecting broad spectrum of mineralised occurrences.
However, geochemical method as it is currently applied, tends to be restricted to shallow targets and sub outcropping deposits.

The advances made in analytical field, especially with the development of spectrometric techniques. Eg. quantometric direct-reading emission spectrometers, plasma emission spectrometers permit simultaneous results of 20-30 trace elements.
INTEGRATED REGIONAL DATA AND
DELINEATION OF PROSPECT

➢ This part is truly a Desk study. All the Available databases on Regional geology, aero geophysical signatures, RS data and mapping are integrated for delineating a prospect.

➢ It is not merely a prospeсting target but possible grade tonnage models are kept in sight before initiating exploration activities on the selected prospect.
2. PROSPECTING:
This includes
- Surveying
- Detailed geological mapping
- Detailed geochemical surveys
- Detailed geophysical prospecting
- Integrated approach
Surveying

- Topographic surveys
- Leveling
- Triangulation
- Contouring.

Survey Instruments

- Compass
- Plane table survey with alidade
- Levelling survey
- Theodolite
- Total Survey station (Electronic Theodolite with Distomat and GRE 4 a-data recorder.)
DETAILED GEOLOGICAL MAPPING (DM)

✓ DM is a prerequisite for taking up subsurface exploration.

✓ We know the broad limits of the prospect.

✓ The DM is done on 2000 or 1000 scale depending on the intricacies of the prospect.

✓ The objective is to map the lithounits that are important from the exploration point of view.

✓ Gold in South Indian green stone belts are associated with carbonate alteration.

✓ Gold deposits in Rajasthan carry tourmalinite and some exotic lithounits that have direct bearing to mineralisation. Such units are mappable only by 1000/2000 scale.
DM is generally accompanied by detailed geochemical sampling on grid pattern, sampling along proposed profile of boreholes, pitting trenching for exposing concealed litho contacts and oxidized zones.

Detailed structural features of local scale are also given importance while mapping the prospect.

Important cultural features are also plotted in a DM.

DM done by triangulation surveys are very accurate.
DETAILED GEOCHEMICAL SURVEYS.

- Geochemical survey is a dedicated method employed for the search and establishing an ore deposit.

- For basemetal exploration group of elements are viz. Cu, Pb, Zn, Ni, Co, Au, Ag.

- For gold – Au, Ag, As, Cu, Hg, W and Zn.

- Scale of geochemical work is very important which decides on methodology (i.e., grid spacing).
<table>
<thead>
<tr>
<th>Type of Deposit</th>
<th>Major components</th>
<th>Associated elements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrothermal Deposits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porphyry copper</td>
<td>Cu, S</td>
<td>Mo, Au, Ag, Re, As, Pb, Zn, K2O</td>
</tr>
<tr>
<td>Porphyry Mo</td>
<td>Mo, S</td>
<td>W, Sn, F, S</td>
</tr>
<tr>
<td>Skarn- Magnetite</td>
<td>Fe</td>
<td>Cu, CO, S</td>
</tr>
<tr>
<td>Skarn-W, Mo, Sn</td>
<td>W, MO, Sn</td>
<td>F, S, Cu, Be, Bi</td>
</tr>
<tr>
<td>Volcanogenic MSD</td>
<td>Zn, Pb, Cu, S</td>
<td>Ag, Ba, Au, As</td>
</tr>
<tr>
<td>Basemetal Vein</td>
<td>Pb, Zn, Cu, S</td>
<td>Ag, Au, As, Sb.</td>
</tr>
</tbody>
</table>
Two scales of Geochem Surveys.

Regional scale and Local scale. However sometimes a third intermediate scale is introduced in special cases.

Depending on the scale the “geochemical anomaly”, which is the final output of the geochemical exploration is graded. Thus you may call an anomaly ‘local’ or ‘regional’, based on whether the survey was done regional or local scale.

The anomaly value is mostly decided by univariate statistics and or multivariate statistics.
SCALE OF GEOCHEMICAL EXPLORATION

- It is a matter of board room decision.
- Regional scale: Involving an area of n\times100 \text{ sq km} (where n=1 to 10 or more)
- Areas >5000 \text{ sq. km} are Regional scale.
- Local nature: Measuring <20 \text{ Sq.km}
- Time and budgetary provisions for analysis of samples are also important.
- Competence level of sampling team and data interpretation party is also of relevance as this data will be integrated to a dedicated GIS software along with other data.
- Once areas are identified, further work can be launched in conjunction with ground GP surveys in smaller blocks of 10-20 \text{ sq.km}.
DETAILED GEOCHEMICAL EXPLORATION:

- The objective is to know the potential.
- Done in regular grid pattern. Medium of sampling is either bedrock or insitu soil (B/C horizon).
- Bedrock sampling is preferred along BH profiles for subsurface correlation.
STREAM SEDIMENT SURVEYS:

✓ Many Exploration companies rely on Stream sediment surveys as this a time tested and reliable method.
✓ Involves selective concentration of useful mineral fraction based on specific physical properties.
DETAIL grid pattern sampling of above area
GEOCHEMICAL ANOMALY.

- It is the final output of Geochemical exploration.
- Such anomalies in a map are either decided by univariate statistics or multivariate statistics.
- An anomaly is a value of the target element generally several orders above the crustal abundance or its statistical population mean.
- The main objective is to locate the anomaly spatially.
- Traditionally an anomaly of an element is defined by univariate statistical mean value and Standard deviation and assigning the values above Mean+2SD).
The recent trend of geochemical anomaly selection depends on multi element data set and multivariate statistics.

The advantage of this method is - the geological influence of mineralisation is more clearly understood and selection of anomalous blocks for detailed exploration is geologically sounder.

The multivariate statistics allows interpretation via geochemical association that is finger printed in the overlying weathering profile.

Apart from this simple contour maps created by geochemical contouring software like Surfer-8 brings rich set of information.

Contouring option is freely used in both regional and local scales.
Cu- anomaly profile

Cu, Pb, Zn, Ni, Co

Dispersion halo

Mn (OH)\(^{-}\) or Fe(OH) or Al(OH) or Humus

Soil

Host rock

Primary mineralisation
Ore bodies frequently differ in physical properties in terms of magnetic susceptibility, electrical resistivity, natural electrical fields, radioactivity, velocity of seismic waves, variation in gravity and mag fields, reflection of E.M waves. Geophysicists use one or more of these measurement to find concealed mineral deposits. The selection of the GP depends on the nature of physical properties of the desired material.
GEOPHYSICAL EXPLORATION

SEISMIC REFRACTION
ELECTRICAL RESISTIVITY
INDUCED POLARISATION
GRAVITY SURVEY
MAGNETIC SURVEY
SEISMIC REFLECTION
MAGNETOTELLURICS

STRATIGRAPHY
ORE BODY MAPPING
DISSEMINATED ORE
HIGH GRAVITY MINERALS
Fe RICH MINERALS
DEEP STRUCTURES, COAL
BED MAPPING
DEEP STRUCTURES, CONDUCTIVE ZONEMAPPING
TYPES OF SAMPLES

• GRAB SAMPLES
• CHANNEL SAMPLES
• CORE SAMPLES
• BULK SAMPLES
PITTING AND TRENCHING

✓ Done to expose the concealed shallow bodies or the causative bodies of the anomaly.
✓ Also done to expose the strike continuity of the linear ore zones. This also gives an idea of the thickness and wall rock characteristics, alteration, grade etc.
✓ Trenches are made at 25-50m strike intervals in detailed stages of exploration.
✓ Samples in the form of channel or groove are collected across the ore zone.
✓ Number of samples depends on the thickness of the ore and mineralogical characteristics.
✓ Trenches are logged, sketches of wall and floors are made and assay values are indicated.
Trench sections depict the nature of disposition of the pyroxenite.
Reflection of soil characters in trench section.
3. EXPLORATION: BOREHOLE PLANNING

Drilling is an important stage of mineral exploration to view the 3rd dimension of the prospect.

As it is a costly venture, this is undertaken only in the advanced stage of exploration.

Diamond drilling is the costliest of all.

This provides complete record of geological structure and rock texture ore quality.

Provides reliable samples for geochemical testing.
HOW TO PLAN BOREHOLES.

- Simple ore Deposits: Homogenous in extent with horizontal to sub-horizontal disposition covering large areas; vertical boreholes in grid pattern of 100X 100 or 200x 200m or 400m by 400m.
- The grid pattern can be modified as per situation and type of data required, nature of the deposit.
- Deformed Ore Deposits: Planning of initial boreholes are important as the fate of exploration depends on initial holes.
- The first few boreholes are planned at the most promising locales of mineralisation.
- The point of intersection of the mineralized zone should be planned to intersect the primary zone below the oxidized zone. Say generally 20-30m from oxidized zone.
In case any old mine exist in the area intersection should be located 20-30m below the deepest level of old workings.

Information from pits and trenches are important for planning boreholes.
BOREHOLE PLANNING IN SIMPLE FLAT BEDDED DEPOSITS
Azimuth Direction

PEGS

Borehole Location
Borehole BH-1 has intersected the apparent thickness of the ore body as BH-1 is not perpendicular to the dip plane. Tap = apparent thickness. Tr = true thickness.
A. BH-2 intersecting the ore body perpendicularly i.e. borehole is perpendicular to the dip plane of ore body B. Shows that borehole is perpendicular to the strike of the ore body. Tr = True thickness
A. The apparent length intersected in borehole BH-3. $T_v$ is apparent length, $\alpha$ angle between core axis and bedding plane. $T_r$ true thickness. B. Surface plan, position of bore hole and inclined ore body.
The case where borehole is perpendicular to the strike of the ore body (B) but incline to dip plane (A). Ti incline thickness True thickness $Tr = Ti \sin \beta$
A. Borehole is inclined to strike (plan) and to dip plane (section)
Fig. : Borehole planning for inclined ore bodies

Fig. 6.16 Borehole on a geological map
The purpose of drilling is:

- To define ore body at depth.
- To access ground stability (geotechnical).
- To estimate the tonnage and grade of a discovered mineral deposit.
- To determine absence or presence of ore bodies, veins or other type of mineral deposit.
Drilling is generally categorized into 2 types:

• Percussion Drilling
  Here a hammer beats the surface of the rock which breaks it into chips.
  - Reverse Circulation Drilling (RC)

  ROTARY DRILLING

This is the type of drilling where samples are recovered by rotation of the drill rod without percussion of a hammer.

  - Diamond Drilling
  - Rotary Air Blast (RAB)
  - Auger Drilling
CORE LOGGING

- The core should be cleaned and wetted.
- Variation in lithology in a run has to be recorded taking into consideration of the core recovery.
- Attitudes of structural features like foliation, bedding, fracture, cleavage etc should be recorded and intersection of these planar structures with core Axis has to be determined.
- If core recovery is less then it should be adjusted.
- Nature of the core broken, fractured, powdery etc should be recorded and RQD has to be recorded.
Mineralised portion of the core should be studied in detail such as nature of mineralisation-stringery, specks, dissemination- and grain size should be mentioned.

Ore minerals identified should be documented. Those difficult may be described in terms of their physical properties.

Visual estimate of ore has to be given. (sulfides, WO3, Pb, Zn etc.)

Sampling zone have to be demarcated.

Size of bit and core to be mentioned

Water loss cavities to be mentioned
Core intersection angle average 40°

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Depth from (m)</th>
<th>Depth to (m)</th>
<th>Recovery (m)</th>
<th>True width (cm)</th>
<th>%Sn</th>
<th>cm%</th>
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<tbody>
<tr>
<td>1</td>
<td>253.66</td>
<td>253.81</td>
<td>0.15</td>
<td>100</td>
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<td>100</td>
<td>12</td>
<td>1.27</td>
</tr>
<tr>
<td>5</td>
<td>254.42</td>
<td>254.65</td>
<td>0.23</td>
<td>100</td>
<td>NIL</td>
<td>-</td>
</tr>
</tbody>
</table>

Weighted average lode value = \( \frac{116.96 \text{ cm%}}{44 \text{ cm (true thickness)}} \) = 2.66% Sn

at a weighted average core recovery of 91%
1. Book Pattern

- 0.00 m to 1.40 m
- 1.40 m to 2.60 m
- 2.60 m to 4.00 m
- 4.00 m to 5.20 m

2. Serpentine Pattern

- 0.00 m to 1.40 m
- 2.60 m to 1.40 m
- 2.60 m to 4.00 m
- 4.00 m to 5.20 m
Recovery = 50%
**CORE ANGLE:**

**Core Axis:** The line passing through the centre of the core in the direction of drilling.

The angle between core axis and bedding/foliation is the core angle (β). This angle is important in for calculation of true width of the unit/zone.
BOREHOLE GEOPHYSICS:

- Very important when core recovery is poor.
- Electrical logging down hole indicates the depth and thickness of ore zones.
- Helps in correlation of ore zones from borehole to borehole.
- Delineation of lithology and interpretation of surface geophysical data.
- EM logging is increasingly used in BGP.
- IP logging also advantageous when the ore is of massive sulfide type and is good conductor.
CORE SAMPLING:

- The core is split into half so that one half is the mirror image of the other.
- After logging the min zones are demarcated and sampling zones are fixed.
- Sample lengths may vary from 25 cm to 50 cm depending on the nature of mineralisation.
- Samples are crushed to -120 to 200 mesh.
- Size of the samples may be reduced by coning and quartering process.
- Half is sent for analysis and the other half is preserved.
Samples are analyzed for

- Quantitative assay of principal constituent
- Semi quantitative spectrum assay of all elements in one.
- 5-10% samples drawn from the same zone with different number for assay check.
- One set of duplicate samples are sent to different laboratory for checking lab bias.
- The other half sample powder is subjected to check analysis.

Composite samples: Combining a number of samples composing is done. Care is taken to collect proportionate weight from each sample.
LABORATORY SCALE EXAMINATION:

- **Physical characteristics**: hardness, Sp. Gr, brittleness etc.

- **Petrological tests**: Petrological and Ore microscope. Thin and polish sections. Ore texture, mineral species, paragenesis, and ore-ore and ore-gangue relation. (In case of gold nature of mineralogical sitting of gold is studied. Free or locked up gold). This will further help in developing ore recovery techniques.

- **X ray and spectroscopic and other method**: For mineralogy which are difficult to determine. Bauxite mineralogy is mainly done by X-ray. X ray fluorescence study is done for identifying scheelite, rare metals.