Model Answer: Mineral prospection and raw materials (435G) exam

Benha University | **4th Year (Sp. Geology) Students**
Faculty of Science | **Mineral prospection and raw materials (435G)**
Geology Department | **Date: 26 – 05 – 2019**
Time Allowed: 2 hours

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Answer the following questions and draw if possible

1. Define only 6 items from the following: **(12 marks)**

a. Mine closure

Mine closure is the last stage in the mineral development cycle.

Mining is a temporary use of the land and all mines eventually close.

Once mining is complete and the mine closes, the land must be left in a safe state that blends with the surrounding environment. This is called reclamation.

Today's mining processes ensure that safe and sound environmental management occurs at every stage of the mining cycle, and in particular, before mining begins.

Environmental technicians, environmental engineers, and specialists who study the soil, water, wildlife and vegetation are examples of career opportunities in the mine closure stage.

b. Ultraviolet lamps

They may cause certain minerals to fluoresce, and is a key tool in prospecting for tungsten mineralization (scheelite and wolframite).

Pure scheelite ($CaWO_4$) has blue-white fluorescence in ultraviolet light,

c. Primary dispersion

It is the process of enrichment surrounding the main ore body having an area of enrichment known as the primary halo

d. Ore reserves

The mineral reserve or precisely ore reserve is that well-defined part of the deposit at specific cutoff after completion of detailed exploration.

The reserve is estimated with a high level of confidence based on detail and reliable information. The sample locations are spaced closely enough to confirm geological and/or grade continuity.

This reserve must be techno-economically viable.

The geological characteristics must be so well established to support production planning.

The deposit can be mined and marketed at a profit.

The metallurgical tests show optimum recovery.

A pre-feasibility/scoping study or feasibility report is prepared to make an investment decision. It includes mine planning, financial analysis including losses associated with mine dilution and metallurgical processing.

e. Cutoff Grade

"Cutoff" is the most significant relative economic factor for computation of resource and reserve from exploration data.

It is an artificial boundary drawing between low-grade mineralization and techno-economically viable ore that can be exploited at a profit.

The cutoff boundaries change with the complexity of mineral distribution, method of mining, rate of production, metallurgical recovery, cost of production, royalty, taxes and finally the commodity price in international market.

Change of any one criterion or in combination of more gives rise to different cutoff and average grade of the deposit.

f. Atmogeochemical Survey

"Vapor surveys" (atmo-geochemical) helps in the location of buried deposits through detection of halos of mercury, helium, nitrogen, sulfur dioxide, hydrogen sulfide, hydrocarbon, radon, methane and other gases and volatile elements, often at a considerable distance from the source of mineralization.

Vapors can be detected from air and soils and in groundwater. Volatile elements are released through oxidation of ore deposits. Common types of anomalies are as follows.

Mercury vapor anomalies can be determined over structurally controlled mineralization in arid terrain.

Hg anomalies are associated with concealed deep-seated high-temperature geothermal system, lead-zinc-bearing sulfide assemblages, and over hydrocarbon gas and oil fields.

Hg gas from the soil can be sampled by precipitation of Hg as an amalgam on extra pure noble metal coils (Ag) in couple of hours and analyzed.

g. Geophysical exploration

Geophysical instruments play a large role in gathering geological data which is used in mineral exploration.

Instruments are used in geophysical surveys to check for variations in gravity, magnetism, electromagnetism (resistivity of rocks) and a number of different other variables in a certain area.

The most effective and widespread method of gathering geophysical data is via flying airborne geophysics.

h. Old Style in the conventional resource/reserve estimation.

The old style method was in practice during past for single vein-type deposit like gold-bearing quartz veins of Kolar and Hutti, Karnataka, India, and gold mines in South Africa.

The auriferous veins are usually either exposed or close to the surface.

The geological and geochemical exploration is supported by few numbers of surface drill holes to establish the existence and continuity of mineralization down depth. The initial entry is by adit, incline and shaft.

The mine levels are developed within the orebody at short vertical interval of around 30 feet.

The extraction levels are suitably located on one side of the orebody based on dip of the lode.

The levels are connected by raises and winzes passing through the mineralization.

Channel and chip sampling is conducted at short interval of 3-6 feet all along the drives and raises.

The reserve= block area × thickness of vein × Sp. Gr.

The grade is computed by averaging all the sample values generated within the block.

2. Answer <u>only two questions</u> from the following: (12 marks)

a. **Compare between Lithogeochemical and Pedogeochemical Survey as a geochemical Survey in mineral exploration.**

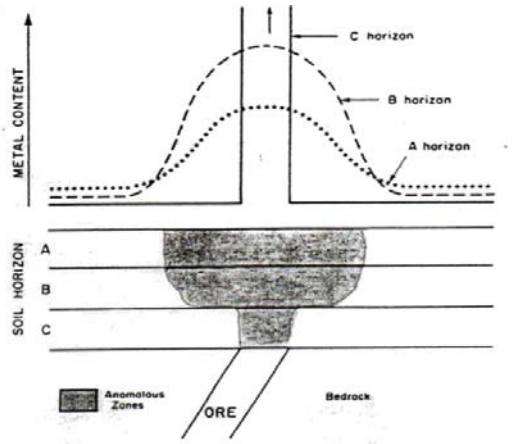
Lithogeochemical Survey	**Pedogeochemical Survey**
Rock sampling is included in the techniques for follow-up because although it has been applied with some success in regional reconnaissance, it is really in detailed work, where there is good outcrop or where there is drill core, that this technique becomes most effective. On a regional basis the most successful applications have been in the delineation of mineralized felsic plutons and of exhalative horizons. Plutons mineralized in copper and	"Pedo-geochemical survey" is also known as "soil survey." Soil is the unconsolidated weathering product. It generally lies on or close to its source of formation such as residual soil. It may be transported over large distances forming alluvial soil. Soil survey is widely used in geochemical exploration and often yields successful results. Anomalous enrichment of elements from underlying mineralization may occur

tungsten are usually enriched in these elements but usually show high variability within a pluton.

It is important that the rock sampling is away from the weathering surficial processes which affected on the elemental distribution as well as the anomalies' locations.

In the hydrothermal deposits, there are usually leaching of the different precious element by the effect of the hydrothermal solution transferring them from the parent rocks to the country rocks leaving haloes surrounding the main mineralized ore bodies.

These haloes extended from cm to different kilometers, therefore main ore bodies are easily determining their location by determining the different haloes and their volume that divided into primary and secondary haloes.



due to secondary dispersion in the overlying soil, weathered product and groundwater during the process of weathering and leaching.

The dispersion of elements spreads outward forming a larger exploration target than the actual size of the orebody.

The fundamental hypothesis is that soil samples are composite products of weathering which cover over the cap rocks. (Cocker, 1996, 1999).

Soils display layering of individual characteristic horizons differing in mineralogy and trace element composition.

Therefore, sampling of different horizons will present different results. The soil profile can be classified in three broad groups such as A, B and C horizons.

“A” horizon is composed of humus charged topsoil with minerals.

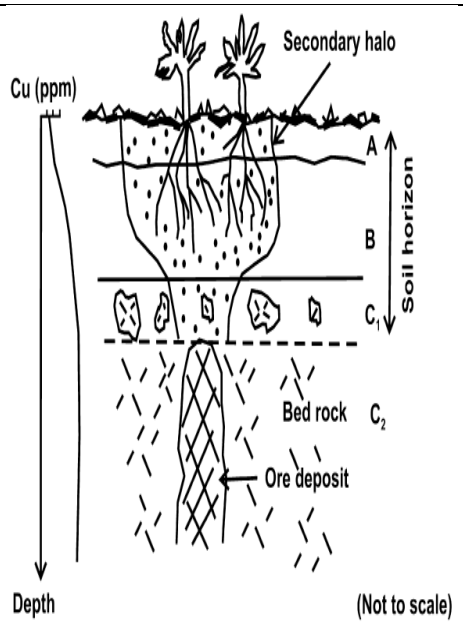
“B” zone represents accumulation of clays enriched with trace elements.

“C” horizon consists of bedrock fragments in various stages of degradation and gradually changes to hard parent rock.

The metal content is generally higher in B horizon than in the A zone. The anomalous behavior of C zone is similar to the parent bedrock. Therefore, samples from B layer enriched with trace elements are most preferred during soil survey.

Soil samples, from residual or transported material, play significant role during reconnaissance survey. It can provide a quick idea about presence or absence of target metals in the environment.

Soil geochemistry as a successful exploration tool was demonstrated in discovery and development of Cu-Au-Mo deposit.

b. **Any orientation survey in any geochemical program should have checklist for evaluating which techniques are effective for the mineral exploration of a commodity sought. (Discuss).**

➢ The best orientation survey is that in which a variety of sampling methods is tested over a deposit of similar geology to the target and in similar topographical conditions to determine the method which yields the best results.

➢ A checklist for an orientation study is given below (Closs & Nichol 1989):

a. Clear understanding of target deposit type;

b. Understanding of surficial environment of the search area;

c. Nature of primary and secondary dispersion from the mineralisation;

d. Sample types available;

e. Sample collection procedures;

f. Sample size requirements;

g. Sample interval, orientation, and areal density;

h. Field observations required;

i. Sample preparation procedures;

j. Sample fraction for analysis;

k. Analytical method required;

l. Elemental suite to be analyzed;

m. Data format for interpretation.

c. **Cross-Section method used as conventional estimation to determine the distinct types of ore reserves and resources. (Discuss)**

- Geological cross-section is a vertical image of the plane across the geological continuity of the area.
- The extent of section is limited by the available surface geological data and borehole information.
- The total surface features such as rock contacts, structures, mineralized signatures, weathering and gossan are plotted with local coordinate system along the surface profile.
- Contours indicate elevation of the profile.
- All the boreholes falling on and around the section are plotted based on its collar coordinate, direction, angle of drilling, deviation and length of the hole.
- Geological cross-section is a vertical image of the plane across the geological continuity of the area.
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- Contours indicate elevation of the profile.
- All the boreholes falling on and around the section are plotted based on its collar coordinate, direction, angle of drilling, deviation and length of the hole.
- The orebody configuration can be very simple consisting of one vein or it can be multiple in numbers and giving a complex type by splitting and coalescing with each other.
- The total mineralized area is divided into several sub-blocks around each borehole intersection by halfway influence principle.
- The area of each subblock is measured by geometrical formulas for rectangular, square and triangular orebody.
- Planimeter is a drafting instrument used to measure the area of a graphically represented planar region by tracing the perimeter of the figure.

- The volume of the subblock is computed by multiplying the third dimension i.e. half of drilling interval on either side.
- The tonnage and average grade of the section is computed by the formula:

$$t = V \times \text{Sp. Gr.}$$

$$V = A \times \text{influence of third dimension}$$

where,

t or T = measured quantity in tonne. V = volume in cubic meter (m3) Sp. Gr. = specific gravity

A = area in square meter (m2)

"Influence" of third dimension is the thickness of horizontal deposit like coal seam, bauxite, placer deposits or drill section interval for base metal deposits.

3. Answer <u>only two questions</u> from the following: (12 marks)

a. **Write on the different forms of risks while exploration process.**

- Any area selected for mineral exploration also carries various forms of sovereign and other associated risks;
- Risk that even if a commercially viable deposit is present, political, environmental and social factors may make the discovery and development of the mineral resource inviable.
- A change in the security of license tenure due to changes in legal, political or other factors;
- changes in local land tenure (such as a declaration of various types of conservation zones);
- outbreaks of social unrest within a country or region (including competition for mineral resources by artisanal miners, who may be operating illegally, or from political resistance from local or non-local organizations, who may or may not be represented or supported locally, but who are opposed to certain, or all, forms of mining);
- changes in tax and other financial conditions subsequent to the conditions which were legally in place at the start of exploration;
- natural disasters such as volcanoes, earthquakes, floods etc.

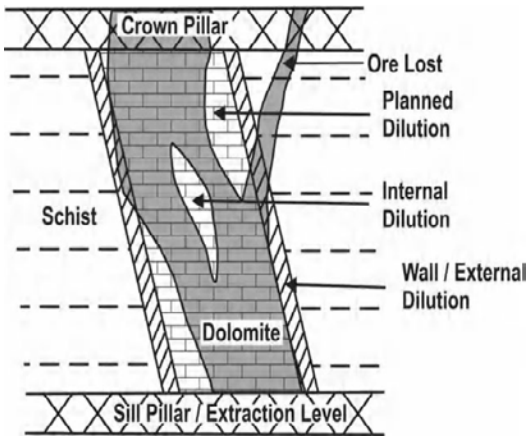
b. Compare between biogeochemical survey and geobotanical survey as a geochemical Survey in mineral exploration.

Biogeochemical survey	**Geobotanical survey**
Biogeochemistry involves the collection and chemical analysis of whole plants, selected parts and humus. During chemical weathering, mobilized elements dissolved and enrich in soils.	A plant will response to its geologic environment in which it grows and may show characteristic variations with respect to form, size, color, rate of growth and toxic effects.

As the plants and trees grow, these dissolved elements, including metals, from the soil are extracted by the roots of the trees which act as a sampling agent. The elements migrate to various parts of the tree such as roots, trunk, stem and finally to the leaves. When the leaves fall to the ground they enrich humus in the metal and the cycle becomes complete. Anomalies indicating buried mineralization can be detected by judicial selection of appropriate parts of the plants (such as roots, bark, twigs, needles, leaves) and subject to analysis.	Geobotany uses these environmental variations. It involves a visual survey of vegetation by recognition of a specific plant population and presence and absence of certain plant varieties associated with particular elements. "Alamine violet" thrives only on zinc-rich soils in the zinc district of Central and Western Europe.

c. **Minable reserve includes different types of planned and unplanned dilution associated during large-scale mining. (Mention them)**

- The minable reserve is very summarized accounting of the quantity and grade present within the stope boundary and finally sum total of all stopes.
- Minable reserve includes all three types of planned and unplanned dilution associated during large-scale mining.
- The "internal dilution" is comprised of narrow low-grade or barren rocks that exist within mineral body or between rich mineral bodies.
- The "external or planned dilution" is the intended addition of extraneous barren rocks outside the ore contacts for uniform designing of blast holes.
- The "unplanned and wall dilutions" are on account of over drilling and blasting beyond designed design, deviation of blast holes, weak and sheared formation at ore contacts.
- The wall dilution can be expected based on past experience with similar mining method, the type and structure of wall rock and rock mechanic studies.
- It is pragmatic to consider all dilution waste at "0" grade to produce a conservative estimate.
- A margin of 5-10% mining loss of ore is expected at the contacts depending on mining methods.



- The total waste dilution can be expressed as:

% Waste dilution = Total waste / Ore

- Some part of ore reserve is blocked in vertical pillars around the shafts/inclines and horizontal Crown/Sill pillars between mining blocks.
- The pillars act as mine support systems.
- It is not considered as ore reserve until and unless it becomes recoverable at a later phase of mine life.
- The category of pillar reserve is then upgraded and merged with minable reserve.

4. The Conventional Classification System classifies the economic ore reserves and sub-economic resources into different types. (Discuss) **(12 marks)**

- The degree of assurance in the estimates of tonnage and grade can subjectively be classified by using convenient terminology.
- In order of increasing geological exploration creating high confidence level and techno-economic viability, the categorization has broadly been grouped as "Economic reserves" and "Sub-economic conditional resources".
- The economic ore reserves and sub-economic resources are further subdivided as ***Developed***, ***Proved***, ***Probable*** and ***Possible***.
- The classification system helps the investor in decision making for project formulation and activities required at different phases.
- These terms are supported by experience, time-tested, and well accepted over years.
- The terminology is comparable with equivalent international nomenclature that is used by USGS or Russian systems as ***Measured***, ***Indicated*** and ***Inferred***.

1. Developed

- The exposed parts of orebody represent "Developed" or "Positive" or "Blocked" reserves.
- Exposure can be by trenches or trial pit on the surface for open-pit mines or bounded on all sides by levels above and below, and connected by raises and winzes on the sides of the block for underground mines.
- Definition or delineation drilling at 30-15 m interval completed and all sides are sampled.
- The risk of error in tonnage and grade is minimal.
- The confidence of estimate is ~90%.

2. Proved

- The "Proved" or "Measured" reserves are estimated based on samples from outcrops, trenches, development levels and diamond drilling.

- The drilling interval would be 200 or even 400 m for simple sedimentary bedded deposits (coal seam, iron ore) with expected continuity along strike, other than structural dislocation.
- The sample interval would be at 50 by 50 m for base metal deposits.
- The deposit is either exposed by trenches or trial pit for open-pit mines and by development of one or two levels for underground drilling.
- Further stope delineation drilling and sampling will continue to upgrade the category to developed reserves.
- The confidence of estimate is ~80%.

3. Probable

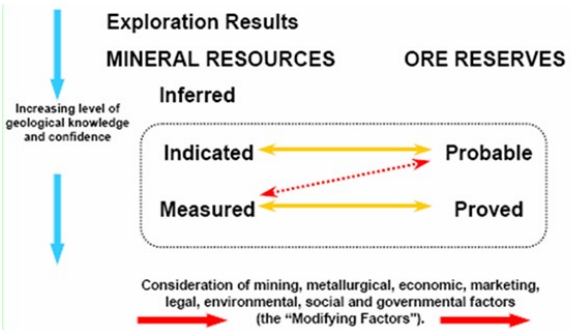
- The "Probable" or "Indicated" reserve estimate is essentially based on wide-spaced sampling, surface and underground drilling at 100-400 m interval depending on the complexity of the mineralization.
- The opening of the deposits by trial pit or underground levels is not compulsory to arrive at this category.
- The confidence of estimate is ~70%.
- The sum total of Developed, Proved and Probable reserve is termed as "Demonstrated" category.
- The reserve of a project under investment decision should contain about 60% in the Demonstrated category.

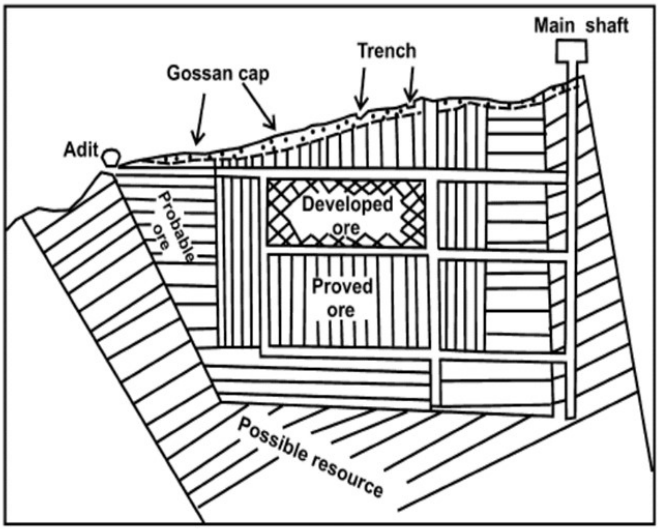
4. Other Ore

- Part of the ore reserve is blocked in Sill, Crown and Rib pillars for stability of the ground during mining operation and related impacts.
- This blocked reserve is designated as "Other Ore" and is monitored as Proved category.

5. Possible

- "Possible" or "Inferred" resources are based on few scattered sample information in the strike and dip extension of the mineral deposit.
- There would be sufficient evidences of mineralized environment within broad geological framework having confidence of about 50%.
- The possible resource will act as sustainable replacement of mined out ore.





With my best wishes
Dr. Amr Abdelnasser