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MINING LEARNING SERIES

Geology & Mineral Exploration

A South African learner's guide to Earth's materials and finding mineral deposits

Prepared by FundaWay Team

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LEARNING OUTCOMES

After studying this note, you should be able to explain basic geology, identify major rock groups, describe the mineral exploration process, compare mapping, geochemical, geophysical and drilling methods, understand resource confidence, and identify South African geology study and career routes.

How to Use This Study Note

This guide introduces geology and mineral exploration for learners interested in mining, Earth science and related careers. Read the sections in order because exploration decisions build from basic observations toward increasingly detailed and costly investigation.

A five-step learning method

Step	Action
1. Observe	Study the photographs, maps, rocks and field evidence.
2. Explain	Describe what each geological feature may reveal about Earth history.
3. Connect	Link geological evidence to exploration questions and decisions.
4. Practise	Answer the revision questions and define every key term.
5. Verify	Use official university, Council for Geoscience and professional sources.

Important caution

EVIDENCE BEFORE CLAIMS

Exploration does not guarantee a mine. A mineral occurrence must be investigated for size, grade, continuity, mining conditions, processing behaviour, economics, legal requirements, environmental effects and community considerations.

How to think like a geologist

Keep observations separate from interpretations. Record what you see first, then propose explanations, test alternatives and update the model when new evidence becomes available.

1. What Is Geology?

Geology is the scientific study of Earth: its materials, structure, history and the processes that shape it. Geologists use evidence from rocks, minerals, fossils, landforms, water, geochemistry and geophysics to reconstruct past events and understand conditions below the surface.

Main branches of geology

Branch	Main question	Mining connection
Mineralogy	What minerals are present and what are their properties?	Identifies ore and gangue minerals.
Petrology	How did a rock form and change?	Interprets the geological environment.
Structural geology	How are rocks folded, faulted and fractured?	Controls deposit shape and continuity.
Economic geology	How and where do useful mineral deposits form?	Guides exploration targets and deposit models.
Geochemistry	How are chemical elements distributed?	Detects anomalies related to mineralisation.
Geophysics	What physical properties reveal the subsurface?	Maps concealed structures and targets.
Hydrogeology	How does groundwater move through rock?	Supports water management and mine planning.

Observation, interpretation and model

EXAMPLE

Observation: quartz veins cut through dark rock. Interpretation: mineral-rich fluids once moved through fractures. Model: similar structures nearby may be exploration targets, but sampling and further evidence are required.

2. Rocks, Minerals and the Rock Cycle

A mineral is a naturally occurring solid with a characteristic chemical composition and crystal structure. A rock is an aggregate of one or more minerals. Ore is material containing valuable components at a concentration and under conditions that may allow economic extraction.

Three major rock groups

Rock group	How it forms	Examples	Exploration meaning
Igneous	Magma or lava cools and crystallises.	Granite, basalt, gabbro	May host magmatic chromium, platinum-group metals, nickel or copper.
Sedimentary	Particles, chemical precipitates or organic material accumulate and lithify.	Sandstone, shale, limestone, coal	May host coal, iron, manganese, phosphates or placer deposits.
Metamorphic	Existing rock changes under heat, pressure and fluids without fully melting.	Quartzite, slate, schist, marble	Can modify, concentrate or deform mineralisation.

The rock cycle

- Weathering and erosion break exposed rock into sediment.
- Burial, compaction and cementation form sedimentary rock.
- Heat and pressure transform rocks into metamorphic rock.
- Melting produces magma; cooling forms igneous rock.
- Uplift and erosion expose rocks so the cycle continues.

MINERAL PROPERTIES

Common identification clues include colour, streak, lustre, hardness, cleavage, fracture, density, magnetism and reaction with dilute acid. One property alone is rarely enough for a reliable identification.

3. Geological Structures and Maps

Rock layers are not always flat or continuous. Tectonic forces can tilt, fold, fault and fracture rocks. These structures may create pathways for mineralising fluids, offset an orebody or influence groundwater and excavation stability.

Feature	Description	Exploration importance
Bedding	Layering formed during sediment deposition.	Provides orientation and stratigraphic position.
Fold	Rock layers bent by deformation.	May repeat, thicken or hide favourable units.
Fault	Fracture with movement on either side.	Can offset deposits or channel mineralising fluids.
Joint / fracture	Crack with little or no visible displacement.	Controls fluid flow, weathering and rock strength.
Intrusion	Magma emplaced into older rocks.	May generate or host mineralisation.
Unconformity	Gap in the geological record.	Marks erosion, non-deposition and possible fluid pathways.

Reading a geological map

- Colours and symbols represent rock units, ages and geological features.
- Contacts show boundaries between units.
- Strike and dip symbols show layer orientation.
- Cross-sections convert map patterns into a vertical interpretation.
- Scale, north direction, coordinates and legend must always be checked.



Field mapping combines careful observation, measurement, sketching and location data. | Source: Field Studies Council

4. What Is Mineral Exploration?

Mineral exploration is the organised search for mineral deposits that may justify further evaluation and possible development. It reduces uncertainty in stages. Early work covers large areas at relatively low cost; later work focuses on smaller targets with more detailed and expensive methods.

Key exploration questions

Question	Evidence needed
Is the geological setting favourable?	Regional geology, known deposits, tectonic history and deposit models.
Is there an anomaly?	Unusual geochemical values, geophysical responses, alteration or mineralised rock.
Does mineralisation continue below surface?	Drilling, downhole surveys, core logging and assays.
How large and consistent is it?	Three-dimensional interpretation, sample spacing, density and continuity.
Could it become a mine?	Metallurgy, geotechnics, water, infrastructure, environment, law and economics.

Target, discovery and deposit

DO NOT CONFUSE THE TERMS

A target is an area selected for testing. A discovery is confirmed mineralisation of interest. A mineral deposit is a natural concentration of material. A mineral resource requires reasonable prospects for eventual economic extraction and must be reported using an accepted code by competent professionals.

5. The Exploration Workflow

Stage	Typical activities	Decision
1. Desktop study	Review geological maps, reports, satellite data, old workings and public geoscience information.	Select favourable regions.
2. Reconnaissance	Field checks, broad mapping, remote sensing and widely spaced sampling.	Keep or reject large areas.
3. Target generation	Combine geology, geochemistry and geophysics.	Rank anomalies and targets.
4. Target testing	Detailed mapping, trenches, pits and initial drilling.	Confirm or reject mineralisation.
5. Delineation	Closer-spaced drilling, logging, assays, density and metallurgical tests.	Define geometry, grade and continuity.
6. Resource evaluation	Geological modelling, estimation, classification and technical studies.	Decide whether further studies are justified.

A stage-gate process

- Each stage should have a clear question and success criteria.
- Data quality and traceability must be checked before interpretation.
- Negative results are useful when they eliminate weak ideas.
- Budgets move toward the strongest evidence, not the most exciting story.
- The geological model must change when observations contradict it.

EXPLORATION RISK

Most targets do not become mines. Sound exploration manages uncertainty, protects people and the environment, and stops work when evidence no longer supports continued spending.

6. Exploration Methods and Tools

Method	What is measured	Typical use	Limitation
Geological mapping	Rocks, structures, alteration and mineralisation at surface.	Builds the geological framework.	Exposure may be poor or weathered.
Remote sensing	Reflected or emitted energy from satellites, aircraft or drones.	Maps landforms, structures and alteration patterns.	Requires ground verification.
Geochemistry	Element concentrations in soil, rock, sediment, water or plants.	Identifies chemical anomalies.	Transport and contamination can mislead.
Magnetics	Variations in magnetic properties.	Maps magnetic rocks, structures and concealed geology.	Interpretations are not unique.
Gravity	Small changes in gravitational field caused by density contrasts.	Detects dense or low-density bodies.	Resolution depends on survey design.
Electrical / EM	Electrical resistance, chargeability or conductivity.	Targets sulphides, structures, water or alteration.	Culture, clay and groundwater can affect results.
Seismic	Travel of elastic waves through rock.	Images layers, faults and deeper structures.	Can be costly and technically demanding.



Geophysical surveys measure contrasts in rock properties to build a testable subsurface interpretation. | Source: Enviroleg South Africa

7. Drilling, Sampling and Core Logging

Drilling tests what lies below the surface. Reverse-circulation drilling returns rock chips, while diamond drilling recovers cylindrical core that preserves geological relationships and structures. The selected method depends on depth, geology, information needs, cost and site conditions.

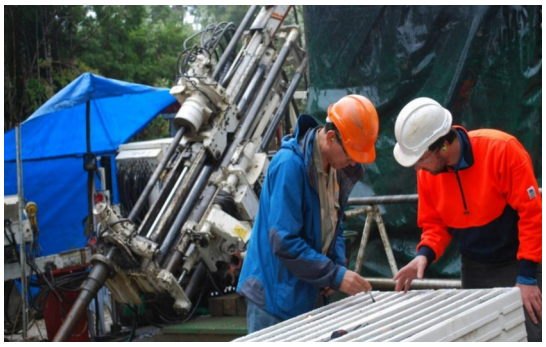
A defensible sample chain

Step	Good practice
Plan	Define hole location, direction, depth, sample interval and safety controls.
Recover	Measure recovery and record any lost or broken material.
Log	Describe lithology, alteration, structure, mineralisation and geotechnical features.
Sample	Mark intervals consistently; cut or split material according to procedure.
Control quality	Insert certified reference materials, blanks and duplicates.
Secure and dispatch	Label, seal, track custody and send samples to an appropriate laboratory.
Validate	Review laboratory quality-control results before using assays.

Why core logging matters

PERMANENT EVIDENCE

Core is a physical record of the subsurface. Photographs, depth marks, orientation, recovery, geological descriptions and sample numbers must agree. Poor logging or lost sample identity can damage the value of an entire drilling programme.



Core logging connects measured depth, rock type, structure, alteration and laboratory assays. | Source: Business News Australia

8. From Discovery to Mineral Resource

Exploration data are combined into a three-dimensional geological model. Geologists interpret boundaries and continuity; estimators use sample results, density and spatial methods to estimate quantity and grade. Uncertainty must be stated clearly.

Concept	Meaning
Cut-off grade	A selected grade threshold used for a particular evaluation purpose; it depends on assumptions.
Tonnage	Estimated mass of material, commonly based on volume and density.
Grade	Concentration of a valuable component, such as g/t, %, ppm or carats per tonne.
Geological continuity	Confidence that a rock unit or mineralised zone continues between observations.
Inferred resource	Lower geological confidence than indicated or measured categories.
Indicated resource	Sufficient confidence for mine-planning and economic evaluation at an appropriate level.
Measured resource	Highest resource confidence based on detailed and reliable evidence.

Resource is not reserve

CRITICAL DISTINCTION

A mineral resource is a concentration with reasonable prospects for eventual economic extraction. A mineral reserve is the economically mineable part of a measured and/or indicated resource after modifying factors and appropriate studies are applied. The SAMREC Code governs public reporting in South Africa.

Data quality supports confidence

- Accurate coordinates, elevations and downhole surveys.
- Representative sampling and reliable assays.
- Density measurements matched to material types.
- Documented quality assurance and quality control.
- A geological interpretation consistent with all relevant evidence.

9. Responsible Exploration

Exploration must comply with law, land-access conditions, health and safety requirements and environmental obligations. Responsible teams engage affected people early, minimise disturbance, manage water and waste, rehabilitate sites and report honestly.

Responsibility	Examples of good practice
People and communities	Respect land users, communicate plans, record concerns and avoid unrealistic promises.
Worker safety	Risk assessments, competent supervision, PPE, traffic controls, emergency plans and safe drilling.
Environment	Limit clearing, protect water, control erosion and spills, manage waste and rehabilitate trenches and pads.
Cultural heritage	Identify and protect heritage sites and follow required procedures.
Data integrity	Record methods, preserve original data, disclose uncertainty and prevent selective reporting.
Legal compliance	Obtain necessary permissions and follow prospecting, environmental and land-access requirements.

Social licence and legal right

A legal permission does not replace respectful relationships. Trust grows through transparent communication, consistent behaviour, listening, grievance processes and evidence that commitments are honoured.

ETHICS IN EXPLORATION

Never alter, hide or selectively report results to make a target appear stronger. Geological decisions affect investors, workers, land users, communities and the environment.

10. Geology Careers and Workplaces

Career	Main focus	Common workplace
Exploration geologist	Generates and tests mineral targets.	Field camps, drill sites and technical offices.
Mine geologist	Controls ore boundaries, grade information and production geology.	Surface or underground mine.
Resource geologist	Builds geological models and supports estimation.	Technical office and site.
Engineering geologist	Assesses ground for infrastructure and excavations.	Construction sites, mines and consulting.
Hydrogeologist	Studies groundwater occurrence, movement and quality.	Field sites, laboratories and consulting.
Geochemist	Uses chemical evidence to study rocks, processes and anomalies.	Laboratory, field and research.
Geophysicist	Uses physical measurements to image the subsurface.	Survey sites, processing office and research.
GIS / geodata specialist	Manages spatial data, maps, databases and visualisation.	Office, government, research and consulting.

Skills employers value

- Field observation, safe work and accurate note-taking.
- Spatial reasoning, maps, cross-sections and three-dimensional thinking.
- Data analysis, statistics, GIS, databases and modelling software.
- Clear reports, presentations and teamwork.
- Scientific curiosity, integrity and willingness to test assumptions.

WORK REALITY

Geology may involve travel, remote locations, heat, dust, uneven terrain and shift or roster work. Other roles are laboratory-, office-, research- or data-focused. Investigate the real workplace before choosing a specialisation.

11. Courses and Study Pathways

Geology is commonly studied through a Bachelor of Science, followed by honours and possibly master's or doctoral study for specialisation. Programme names, majors, admission requirements and professional pathways differ by institution.

Institution	Example 2026 route	Published note
University of the Witwatersrand	BSc Geological Sciences	Three years, full-time. Geology can lead toward mining and exploration geology, geochemistry, geophysics and other geosciences.
University of Pretoria	BSc Geology	Three-year programme; UP also publishes a four-year extended BSc Geology route.
University of Pretoria	BSc Environmental and Engineering Geology	Combines Earth science with resource, groundwater and engineering applications.
Wits postgraduate	BSc Honours and MSc Economic Geology	Specialist study can deepen exploration, geophysics, economic geology or research skills.
UNISA / related technical study	BSc options and mining-geology modules within relevant qualifications	Confirm the current qualification structure, module combinations and admission rules directly with UNISA.

School preparation

- Prioritise Mathematics, Physical Sciences and strong English communication.
- Geography, IT, coding and field-science exposure are useful additions.
- Practise graphs, scale, coordinates, trigonometry, chemistry and data interpretation.
- Check each university APS, subject levels, closing dates and selection rules for your intended year.

VERIFY BEFORE APPLYING

The programme examples above were checked from official pages available in August 2026. Requirements can change. Download the current prospectus and confirm programme status, campus, duration, fees, funding and admission rules with the institution.

12. Key Terms and Revision

Quick glossary

Term	Meaning
Anomaly	A measurement that differs significantly from expected background values.
Assay	Laboratory determination of the amount of one or more components in a sample.
Alteration	Mineralogical or chemical change in rock, commonly caused by fluids.
Gangue	Non-valuable minerals occurring with valuable minerals.
Mineralisation	Formation or presence of minerals of potential interest.
Ore	Material that can be mined and processed economically under stated conditions.
Prospect	An area where evidence justifies more detailed exploration.
QA/QC	Procedures used to monitor and demonstrate data quality.
Strike and dip	Measurements describing the orientation of a planar geological feature.
Tenement / prospecting right	A legal area or permission for authorised exploration activity.

Revision questions

- 1. Explain the difference between a mineral, rock, ore and mineral deposit.
- 2. Compare igneous, sedimentary and metamorphic rocks.
- 3. Explain how faults and folds can affect exploration.
- 4. List the six main stages of the exploration workflow.
- 5. Compare geological, geochemical and geophysical methods.
- 6. Why must a geophysical anomaly be drilled or otherwise tested?
- 7. Describe the sample chain from drilling to validated assay.
- 8. Explain resource confidence and why resource is not reserve.
- 9. Give five examples of responsible exploration practice.
- 10. Choose one geology career and prepare a Grade 10-12 study plan for it.

FIELD ACTIVITY

Choose a safe exposed rock or building stone. Photograph it, describe colour, grain size, minerals, layering, fractures and weathering, record the location, and clearly separate observations from interpretations.

13. References

Sources were checked on 17 August 2026. Programme rules, legislation and reporting requirements change; always verify current official information.

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Image credit - Field Studies Council. Geology field measurement photograph used in Section 3. https://www.field-studies-council.org/

Image credit - Enviroleg South Africa. Electrical resistivity survey photograph used in Section 6. https://enviroleg.co.za/electrical-resistivity-tomography-ert-survey-prices/

Image credit - Business News Australia. Drill-core inspection photograph used in Section 7. https://www.businessnews.com.au/article/venture-adds-rare-earths-to-tasmanian-tin-play

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Learn Today, Achieve Tomorrow. Use this note to begin your research, then verify your personal study plan with official institutions, the Council for Geoscience and trusted career advisers.