

Mining Matters II - The Earth's Crust
Une mine de renseignements II - L'écorce terrestre



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PROSPECTORS AND DEVELOPERS ASSOCIATION OF CANADA MINING MATTERS,
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About PDACMM

Prospectors and Developers Association of Canada Mining Matters (PDACMM) is a registered charitable organization (Reg. No. 88775 6435 RR0001) whose activities are directed toward:

- educating students about Canada's geology and mineral resource endowment and promoting awareness of the importance of rocks, metals, minerals and mining through the dissemination of information and the development and distribution of educational programs and material, and
- co-ordinating with other charitable, educational or governmental agencies or organizations in developing education programs and material.

PDACMM has created three teacher resource units since 1994: Mining Matters, Deeper and Deeper and Mining Matters II – The Earth's Crust.

Mining Matters / Une mine de renseignements was originally written in 1994 under the Ontario Common Curriculum. It was an integrated, activity-based unit that introduced Grade 6 and 7 students to the world of rocks, minerals, Earth Science and the minerals industries. While this unit continued to meet most of the Science and Technology Expectations of The Ontario Curriculum Grades 1-8, teachers felt they needed a new science unit to match 100% of the Specific Expectations and encouraged **Prospectors and Developers Association of Canada Mining Matters** to design a new resource.

A team of teachers was assembled early in 2001 and the work began, designing a science unit using the successful model of Mining Matters and the Grade 4 program, Deeper and Deeper. The key elements of the model included having experienced classroom teachers design the lessons and activities. Industry and government earth scientists reviewed the work for technical accuracy and provided information and access to sources for samples and print resources to enhance the learning experience.

With the help of industry and volunteers, 500 English copies of the **Mining Matters II - The Earth's Crust** resource kits were assembled in the summer months of 2001 and are now being used throughout separate and public school boards across Ontario. As well, 200 French language kits were also assembled and are awaiting translation of the Teacher Resource materials before distribution can be completed. In the summer of 2002, **PDACMM** will fulfill its mandate with the creation of another 700 English kits to satisfy the large number of school boards now on our waiting list. At **PDACMM**, it continues to be our goal to provide teachers with the most complete and useful instructional resources possible for the teaching and promotion of Earth Science in Ontario's classrooms.

This information package includes: an introduction to **PDACMM**; the Table of Contents from the Teacher Resource binder; a list of unit materials and resources provided within each kit; a topic

overview; an example of a complete lesson plan, (including Information Bulletin and Student Activity); and a section of both the Glossary and Sample Test Questions.

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Unit Materials and Resources

Most of the visual materials, rock and mineral samples, testing equipment required to complete the activities and supplementary resources have been included in the kit. It is expected that consumable materials and scientific equipment will be supplied by the school. It is recommended that teachers who are not familiar with common minerals and rocks label the samples according to a number code before starting the unit. Special care should be taken to ensure that the rock and mineral samples are returned to the kit for future use. Experience shows that samples sometimes go missing; therefore, teachers may request replacement rock and mineral samples but full sets of samples cannot be replaced - supplies are very limited.

The ***Mining Matters II - The Earth's Crust*** kit comes assembled in a plastic storage box containing:

TEACHER'S BINDER:

includes the Lesson Plans, Activity pages, Information Bulletins, diagram masters and colour overhead transparencies

ENVELOPES:

Student Visuals: containing 10 copies each of the Common Fossils card and Geology and Principal Minerals of Ontario map card

Additional Resources: containing display posters (Minerals at Work, Home and Play, Gems and Minerals, Mine Types), brochures (Aggregate Producers' Association of Ontario), fact sheets and information pamphlets

VIDEOS:

National Film Board of Canada Compilation of three segments; Face of the Earth (17:02), Moving Plates & Continents (2:43) and Volcanism (4:17)
Common Ground (with accompanying teaching package)
Careers in the Minerals Industry
Going Up

BOOKS:

Mining Explained
Rock ONtario

PLASTIC BAGS:

Equipment Package:

2 each of magnifiers, nails, pennies, Mohs Scale, magnets, streak plates and conductivity tester (needs to be assembled)

Mineral Samples (11 bags)

3 samples per bag - amethyst, talc, barite, quartz, mica, halite, chalcopryrite, calcite, magnetite, feldspar and hematite

Rock Samples (13 bags)

3 samples per bag

Igneous - Intrusive (from magma) - granite, gabbro Extrusive (from lava) - basalt, rhyolite,

Sedimentary - sandstone, shale, limestone, dolostone, conglomerate

Metamorphic - gneiss, marble, quartzite, slate

OTHER RESOURCES:

Natural Resources Canada - Principal Mineral Areas of Canada map

Getting Started: An Overview with Important Information for Lesson Preparation

Topic Descriptions

Topic 1.0 - The Earth's Crust: The Big Picture

This introductory section provides a general overview of the earth and its crust. The section looks at the layers that make up the earth as well as the dynamic nature of the earth. The video, *The Face of the Earth*, provides excellent visual reinforcement of the movement and mountain building processes that continue today.

Topic 2.0 - The Forces Within The Earth's Crust

This section highlights the importance of understanding that the earth is a dynamic planet containing enormous forces. These forces produce the landforms with which we live. The video *Moving Plates and Continents* introduces students to the dramatic processes within the earth, which affect our planet. The concept of convection and the development of the plate tectonics theory are introduced. The effects of tectonic activity are explored, specifically mountain formation and the processes of folding and faulting - deformation of the earth's crust. All lessons stress the everyday relevance of such studies.

Topic 3.0 - Earthquakes and Volcanoes

Topic 3 introduces students to volcanoes, earthquakes and geothermal energy by presenting explanations of the processes involved. Students learn, through hands-on activities, how the release of energy from moving earth's plates can create an earthquake and how heated water beneath the earth's crust escapes to the surface as a result of geothermal energy. Overheads and lecture material present a clear picture of the devastation by volcanic hazards associated with eruptions. A research paper asks students to use multimedia to investigate a volcanic or an earthquake event.

Topic 4.0 - The Changing Face of the Earth's Crust

This section deals with the three rock types; igneous, metamorphic and sedimentary, and the ways in which these rocks are altered through the rock cycle. Students will learn to observe and record the different characteristics of rocks and to use these characteristics to identify rock samples. Students will also learn how, why and where fossils are formed and how they are used in Earth Science.

Topic 5.0 - Minerals: The Building Blocks of Rocks and Much More!

Students learn how to distinguish rocks and minerals and the importance of minerals. Students investigate the world around them to discover all the items made with minerals. After the teacher demonstration of the characteristics of minerals, students are expected to identify, through testing a suite of minerals.

Topic 6.0 - The Earth's Resources

Mining is an important industry, which has an economic, environmental and social impact on our daily lives. The video **Common Ground** introduces the changing attitudes towards the environment and how mining has responded to these changes. Students' perceptions of mining are developed with the presentation of facts about mining in the past and present. The video **Going Up** provides valuable information about current mine technology. Related concepts including reclamation, rehabilitation and recycling are presented through hands on activities and integrate the idea that mining and environmental responsibilities are not mutually exclusive. Students will design rehabilitation plans and learn about community recycling programs in order to enhance understanding that the earth's resources are limited.

Topic 7.0 - Ontario's Geology and Landscapes

This topic introduces students to the geology of Ontario and helps students focus their attention on the geology around their cities and towns. Lessons 7.2 and 7.3 highlight the processes that shape and sculpt our landscape, including glaciers, weathering and erosion. Lesson 7.3 delivers a detailed study into the processes of weathering and erosion and acts as a bridge to the subsequent topic of soils.

Topic 8.0 - Soils: Cultivating Life on the Earth's Surface

This section looks at how soil is formed and the various characteristics of different soil types. The students investigate some of the characteristics of soil including texture, water-holding capacity, the presence of air in soil, and capillary action in soil. Soil types, uses and soil conservation are investigated.

Topic 9.0 - Wakima - A Discussion on Development

This section is built around the proposed opening of a fictional mine. The mythical town of Wakima is introduced along with the details of the surrounding area. Students are asked to take on the identity of an interest group and to develop a debate presentation that puts forth their viewpoint, which is either in favour or opposed to the opening of a mine in the area. This section includes map work, group discussion and oral presentations. Students are asked to analyze the facts to support their personal opinion as to whether or not the mine should be opened.

Lesson Plan and Activities

Each lesson plan addresses a specific expectation from the Ontario Science and Technology curriculum and provides a comprehensive and organized template for teachers. Lessons include a general plan with activity guidelines and may have information bulletins, student activities, diagrams and accompanying overheads.

2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Lesson Plan

Specific Expectations:

Students will:

1.7 Understand and be able to describe the processes involved in mountain formation and in the folding and faulting of the earth's surface.

Lesson Objectives:

Students will:

- Participate in teacher-led discussion about plate tectonics based on the **Information Bulletin**.
- Answer questions based on written text.

Materials Required:

From the kit:

- **2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Information Bulletin**
- **2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Activity**
- **Overhead 2.2/3.5 Tectonic Plates**
- **Diagram 2.2/3.5 Tectonic Plates**
- **Diagram 2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust**
- Optional - **ROCK ONtario** - can supplement **Information Bulletin**

Other:

- Overhead projector

Preparation and Set-up:

- Set up the overhead projector.
- Have a globe or world map in the classroom so that you can visually show the class how the continents fit. Make class sets of the **Information Bulletin**, the **Activity Sheet** and the **Diagrams 2.2/3.5 Tectonic Plates** and **2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust**.
- Preview the **Information Bulletin**.

Glossary Terms

Basic Terms: Pangaea, continental drift, convection, plate tectonics, hot spot, mid-Atlantic ridge, subduction zone, fossil

Secondary Terms: paleontologists, meteorologists, geologists, hypothesis

Pre-Teaching/Review:

- Review the **Information Bulletin**.

Activity Guidelines

- When describing Pangaea and continental drift show a globe and the placement of the continents. The diagram will be useful here since it highlights the constant movement and changes of the earth's surface.
- The **Shifting Plates Supplementary Activity** described below will take several periods since the full class time will not be devoted to it. It may be a good way to spend the last 15 minutes of 2 or 3 classes.

Assignments:

Students are to complete **2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Activity**.

Additional Information:

<http://geology.er.usgs.gov/eastern/tectonic.html>

-Details on the development of plate tectonics theory and how it affects daily life. It also has informative maps and reference lists.

<http://master.ph.utexas.edu/vicki/studw.htm>

-Excellent site for graphics concerning plate tectonics.

Optional Activity:

Shifting Plates Supplementary Activity - Make a tectonic jigsaw

Equipment:

- Thick cardboard (side of old cardboard box)
- Craft knife
- World map
- Pens and pencils
- Tracing paper

Procedure:

1. Copy a map of the world onto tracing paper with a red pen. Then turn the paper over and rub the pencil firmly back and forth across the back of the red line.
2. Turn the tracing paper back onto the right side and place it on the piece of thick cardboard.
3. Draw over the outline of the world map again, pressing down firmly as you do so. The pencil on the back of the tracing paper will transfer onto the cardboard.
4. BE CAREFUL when using the craft knife to cut around the continents, CUT AWAY FROM YOU AND HOLD THE CARD FIRMLY.
5. Using these continental jigsaw pieces, arrange the continents so that they fit together as a single land mass (i.e. create Pangaea).

2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Information Bulletin

When we look at a map of the world or a globe we can see that the earth has seven continents. However, when we look more closely we can see that the eastern coastline of South America and the western coastline of Africa fit together like pieces of a jigsaw puzzle - if the Atlantic Ocean were removed and the continents were put together. There are other matching outlines where Canada would piece together with Greenland if the Atlantic Ocean did not separate them. Is it possible that at one time the continents were actually a single land mass with no oceans between them?

Alfred Wegener, a German meteorologist, believed that the continents fit together in the past. Paleontologists found the same type of fossils in both South America and Africa, and guessed that the continents were once connected. Wegener had always wondered about the jigsaw-puzzle fit of the continents and this together with the paleontologist's findings led him to come up with a hypothesis or scientific idea called **continental drift**. Wegener's theory proposed that at one time all of the continents had been united - a supercontinent - which he named **Pangaea** - and that about 200 million years ago it had begun to break into individual pieces, or continents, slowly moving into their present position, the gaps between the continents becoming oceans. In 1928, a British geologist named Arthur Holmes published an article that discussed a force that could explain how the continents were driven apart. Holmes proposed the presence of thermal **convection** currents, or currents of heat, in the interior of the earth. According to Holmes, these currents rose from the interior of the earth to the base of the continents, stretching and breaking the continental masses apart.

In 1963, the idea of continental drift was further developed into the concept of **plate tectonics** by Canadian earth scientist Tuzo Wilson who taught at the University of Toronto and was the director of the Ontario Science Centre until his death in 1993. His main contribution to the theory of plate tectonics was the recognition of **hot spots** in the mantle. The chain of Hawaiian islands formed a hot spot in the Pacific ocean. Wilson's idea is regarded as one of the main advancements in thinking about how the earth works.

Convection forces move the major plates of the earth's crust. As the plates move, their boundaries behave in two general ways - divergent (spreading) and convergent (colliding). New crust is generated at divergent plate boundaries as the plates pull apart. An example of this is the **Mid-Atlantic ridge** in the middle of the Atlantic ocean floor which behaves like two giant conveyor belts slowly moving in opposite directions as they transport newly formed oceanic crust away from the ridge crest at about 3 cm per year. The size of the earth has not changed implying that the crust must be destroyed at about the same rate as it is being created. Such destruction (recycling) of crust takes place along convergent plate boundaries where plates are moving toward each other, and sometimes one plate sinks under another. The location where sinking of a plate occurs is called a **subduction zone**. Volcanoes are often located on the surface of the earth above a subduction zone. Other times when plates collide they crumple up along their edges, creating mountains. An example of a convergent plate boundary is along the west coast of Canada where the Pacific plate is sliding under the North American plate.

Sources:

http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/introduction.html

Volcano World. This site provides a very good set of lessons and diagrams.

<http://pubs.usgs.gov/publications/text/dynamic.html>

US Geological Survey. This site provides a very comprehensive and excellent source of information and diagrams regarding the theory of plate tectonics.

2.2 Tectonic Plates - The Moving Foundation of the Earth's Crust Activity

1. In a short paragraph (5-6 complete sentences) describe the development of the Plate Tectonic theory from its origins in the hypothesis of Continental Drift.

2. What is a spreading boundary? Describe the location of two examples of this type of boundary.

3. Define in complete sentences:

Pangaea

continental drift

tectonic plates

subduction zone

4. What two land masses did Pangaea break-up into and how many years ago did that occur?

Glossary of Definitions

A Specific Expectation of the Ontario Grade 7 Science and Technology Curriculum concerns the proper understanding and usage of relevant terminology for Earth Science.

Specific Expectation:

2.4 Use appropriate vocabulary, including correct science and technology terminology to communicate ideas, procedures, and results (e.g. use terms such as, magma, crystallization, igneous rock, weathering, transportation, sediments and sedimentary rock when describing the rock cycle).

In order to fulfil this expectation, a Glossary Terms section that highlights all relevant terminology is included for each activity and a Glossary of Definitions is included in the unit.

Word	Definition
A Horizon	The uppermost horizon of a soil profile, also called topsoil
Aerial Photographs	Photographs that are taken of the surface of the earth from an airplane, or helicopter.
Aggregate	Rock, mineral particles, or a mixture of both; Hard materials such as sand, gravel, crushed stone that can be used to form cement or plaster in construction.

Amber	A clear yellowish-brown substance that formed from the hardening of tree sap.
Analysis	Examination and interpretation of facts or observations.
Anomalies	Areas on the surface of the earth, or below, that have different properties than around it. (e.g. one spot on the earth may be highly magnetic while the area around it is not magnetic at all).
Anticline	An upward fold ('n' shape) of layered rock in which the sides slope down and away from the crest; the oldest rocks are in the center, and the youngest rocks are on the outside.
Ash	Very fine-grained particles that are ejected out of a volcano (volcanic ash).
Assay	A test that analyses the amount of metal or element (e.g. gold, silver, lead) in an orebody or rock.
Asthenosphere	The zone or layer of the earth's upper mantle that lies below the lithosphere. It is weak, capable of deforming plastically and magma is generated here.
Atmosphere	The collection of air and gases that surrounds the earth.
B Horizon	The mineral horizon of a soil, also called the subsoil, located below the A horizon.
Basal Sliding	Glaciers can move by basal sliding where the glacier slides as a large block on its base over the underlying rock. The glacier moves much the same as a wet bar of soap down a slanted table.
Basalt	A fine-grained igneous extrusive rock that flows out of volcanoes or mid-oceanic ridges.
Bedrock	Solid rock which underlies layers of soil, gravel or other material on the surface of the earth.
Bench	"Steps" that are built into the sides of an open pit mine to stabilize the walls of the pit and avoid collapse.
Body Wave	A seismic wave that travels through the middle of the earth spreading out in all directions.
Bomb	A blob of lava thrown out of a volcano as a hot liquid which forms a round shape as it cools flying through the air.
Brachiopods	Clam-type shelled animals that lived on the sea floor millions of years ago.
C Horizon	The soil horizon below the A and B horizon which consists of weathered parent material like till, sand, gravel and bedrock.
Cage	A type of elevator compartment used to transport miners and equipment from the surface to the underground mine.
Capillary Action	The attraction of the surface of a liquid, like water, to the surface of a solid, like soil or paper, which causes the liquid to climb-up the soil.
Cinder Cone Volcano	A cone shaped hill or mountain formed by the accumulation of rock and ash ejected out of a volcano.
Clast	An individual sedimentary rock fragment or piece that has been broken off a larger rock.

Clay	Another name for mud. An extremely fine-grained sediment with each individual grain having a diameter of less than 0.002 mm.
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Appendix B - Sample Test Questions

Rather than provide a prescriptive end of unit test, it was decided to supply a series of possible quiz and test questions that could be used by the teacher in a variety of ways. The questions are organized by topic and within each topic there are a number of true/false, multiple choice, fill in the blank, definition and sentence/paragraph questions. Answers for each question are italicized and in square brackets. A suggested marking scheme is proposed for the sentence/paragraph questions. Teachers are encouraged to design additional questions based on the specific classroom experience.

Topic 1.0 The Earth's Crust: The Big Picture

True/False:

- The centre of the earth is called the inner core. [T]
 The inner core is believed to be made of magma. [F]
 The crust of the earth varies between 5 and 50 km thick. [T]
 Convection currents occur in the outer core of the earth. [F]
 Earthquakes result only from subduction. [F]
 The Rocky Mountains are sedimentary mountains. [T]

Multiple Choice:

- The earth is made up of: [d]
 a) 3 layers c) 4 layers
 b) 5 layers d) 3 layers and an inner core
 Magma is: [c]
 a) cooled lava c) molten rock
 b) liquid iron d) molten iron
 The internal temperature of the earth: [c]
 a) is constant throughout c) changes depending on the layer
 b) is hottest in the mantle d) is 1870 0C
 The earth's crust is: [d]
 a) made of rocks c) made of soil
 b) made of sand d) made of all of the above
 Geysers are created by: [c]
 a) volcanoes c) water heated by hot rocks below the surface
 b) earthquakes d) erosion

Fill in the Blank:

- The earth's crust is [5] km to [50] km thick.
 Molten rock is also called [magma] or [lava].
 Volcanoes often release gases, ash and [lava].
 Hot springs and geysers indicate that there is [heat] below the surface of the earth.

Definitions:

- Crust [*The outermost surface layer (approximately 5 - 50 km thick) of rock, sand and soil that covers the earth*].
- Mantle [*Zone within the earth that lies below the crust and above the core*].
- Lithosphere [*The outer, solid shell of the earth. It lies above the asthenosphere and contains the crust (continents) and plates (continental and oceanic)*].
- Magma [*Molten rock material generated within the earth's asthenosphere. When magma hardens or solidifies it becomes an igneous rock*].
- Lava [*Molten rock that erupts out of a volcano or from a crack in the earth's surface*].
- Folding [*The bending of rock layers usually due to compression*].

Sentence/Paragraph:

Explain how convection currents in the mantle create and move the earth's crust.

{4 marks}

[The crust is split into plates that float on the mantle. Where the mantle's convection currents rise, the plates move apart and new crust is formed. Where the currents fall, one plate is pulled down under the other plate. As the currents move in a circular motion within the mantle, the earth's crust, floating on the mantle, moves as well].

Explain the difference between "magma" and "lava". {2 marks}

[Magma is molten rock that is found beneath the earth's crust. Lava is molten rock that is or has been pushed to the earth's surface, usually by volcanic action].

What evidence is there that the earth is hot below the crust. Provide at least 3 examples.

{3marks}

[Volcanoes, hot springs, geysers, and boiling mud indicate that below the earth's crust there is great heat].

Completely explain the process that created the Rocky Mountains. {6 marks}

[Over the course of millions of years, land was eroded and slowly washed away by rain. This sediment was carried to the seas where it was laid down in layers. The pressure from the water and overlying sediment caused the sediments below to become rock. Convection currents moved the Pacific plate which collided with the North American plate. The collision caused the Pacific plate to be forced under the North American plate and caused the leading edge of the North American plate, composed of sediments, to be thrust upwards, forming the Rocky Mountains. This process continues today].