CHAPTER 1: INTRODUCTION TO GEOLOGY ***Name: ________***

<u>Physical geology</u> is concerned with the materials and physical features of the Earth and the processes that bring about these changes.

Even though geology includes many aspects ofW chemistry, biology, and physics, it is unique.

<u>Time</u> and <u>scale</u> are probably the two hardest factors to overcome in the study of geology. Some geological processes may take millions of years. Therefore, they cannot be studied in a lab. Experiments must be theorized a lot of the time. Also, it is impossible to bring a tectonic plate or volcano into a laboratory. So, either a lot of field studies are done or scale models are created.

In a chemistry experiment, it is relatively easy to control all the variables. However, in a geological system, it is nearly impossible. A geological system is an open system where matter and energy travel in and out all the time. Temperature and pressure also changes regularly.

<u>How do we study geology?</u>

We use ***<u>"the present as the key to the past".</u>*** This approach is called <u>uniformitarianism</u>. We look at geologic processes of today and see the rate of change. We assume that the same physical principles have been operating from past to present.

Some scientists believe in <u>catastrophism</u> but it has been largely discounted. Catastrophism means that the earth was static and was not forever changing. Then, large catastrophic events such as comets hitting Earth, earthquakes, or violent volcanic eruptions occurred and changed the Earth.

Here are some changes that are currently occurring on and within the Earth:

- The Earth is slowly losing heat and has ever since it formed. Since the heat has changed, volcanic action and rate of cooling of substances have probably also changed. However, it's important to note that the interior of the planet is still extremely hot (approximately 7000^{o}C).

- Earth's atmosphere has also changed, going from oxygen-poor to oxygen-rich.

QUESTIONS:

1. What is geology?

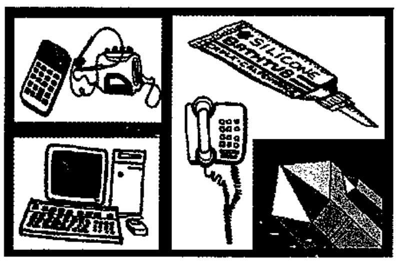
2. What makes geology different from other sciences?

3. What is uniformitarianism?

4. How does uniformitarianism differ from catastrophism?

Read the following article. As you go through it, highlight any sections that you feel are particularly important or thought-provoking. We will be discussing it tomorrow in class.

ARTICLES



The Earth and its People: Repairing Broken Connections

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SUMMARY

Humans are losing touch with the Earth. They tend to ignore the strong linkages between earth resources and the level of civilization they enjoy. They also tend to ignore the forces of earth processes, rendering themselves insensitive to natural processes and hazards. The disconnection is strongest in the developed, first world of which Canada is a part. Earth scientists hold the key knowledge to repair this disconnection between the Earth and its people. It is critical that we place more of a social context on earth science, especially as it is communicated to the public. We need to re-establish the connections between our well-being and the earth resources that make it possible. We also need to educate society about how Earth processes affect our everyday life. By the same token, we also need to elaborate more of the social context of earth sciences to students of earth sciences.

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RÉSUMÉ

Les humains perdent de plus en plus contact avec la Terre. Ils ont tendance à oublier les liens importants qui existent entre les ressources de la Terre et le niveau de vie dont ils jouissent. Ils ont aussi tendance à ignorer les grandes forces des mécanismes terrestres en jeu, ce qui les rend inconscients des processus et des dangers ambiants. Cette inconscience est d'autant plus prononcée que le pays est développé et, le Canada est l'un des premiers pays de la liste. Les géoscientifiques détiennent le savoir clé permettant de rétablir la conscience des liens existant entre la Terre et ses habitants. Il est crucial que nous fassions l'effort de mieux situer les sciences de la Terre dans leur contexte social, particulièrement à l'occasion de communications à l'intention du grand public. Il est impérieux que nous réussissions à re-démontrer l'existence des liens entre notre bien-être, et les ressources terrestres dont il est issu. Il est également nécessaire que nous instruisions la société sur le mode de fonctionnement des processus terrestres qui affectent quotidiennement nos vies. Par la même occasion, nous devons insister davantage auprès des étudiants sur les applications sociales des connaissances géoscientifiques.

THE BROKEN CONNECTIONS

Human inhabitants of the Earth, especially those who live in urban centres of first world countries, do not seem to have a clear understanding of the relationship between their civilization and the use of Earth's resources. Most humans no longer make the connection between the exploration, development, and consumption of Earth resources and their personal comfort and well being. In fact, we now face a situation where many decision makers think of natural resources as a thing of the past, inherently dirty and inefficient, and perhaps more in tune with the industrial revolution of the 19th century. They believe the 20th century represented the transition from that dirty, resource-consuming, industrial age to the brand-new, globally connected, technologically advanced, information age. They distinguish an old and a new economy on this basis (see Nowlan, 1998). The 21st century, they think, is to be characterized by this clean and efficient information age. They fail to connect our current level of civilization and technological sophistication to the Earth resources necessary for their construction. In other words, they see computers as a kind of abstract clean tool of the future, not realizing that the plastic box, the circuitry, the drives, and the chips are made of resources that come from the Earth (Fig. 1).

Worse yet, they seem to miss the connection between the consumption of coal, hydrocarbon, uranium or water resources, and the provision of power necessary for our civilization. Our society not only shows disregard for the value of

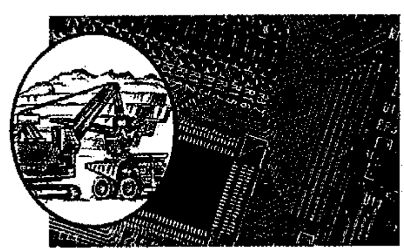

Figure 1 People regard computers as clean abstract tools of the future, not realizing that the plastic box, the circuitry, the drives, and the chips are made of resources that come from the Earth.

natural resources but also tends to stress the negative environmental consequences of extracting and using those resources. It doesn't help that earth scientists have been so good at finding those resources that over the last 20 years, they have proved inexpensive. The recent rise in the price of oil and gas and electrical generation has been highly illustrative of first world attitudes to resources. Instead of encouraging people to reduce consumption in the face of high prices, governments at all levels are providing rebates to consumers in order to cushion them against increased cost. If people had to pay more for the resources they use, they would value them more highly. Earth scientists know the importance of resources, and the importance of managing those resources well; they must convince their fellow citizens of the intimate connection between human civilization and the Earth's natural resources. We have used these resources from prehistoric times to the present: the nature of the most sought-after resources may have changed over time, but their importance for human survival and development has not (Fig. 2).

Similar kinds of disconnections between people and the Earth render them insensitive to natural earth hazards. These disconnects allow them to build dwellings or business structures in totally inappropriate places and then expect governments to bail them out when their structures are destroyed by landslides, coastal erosion, volcanic eruptions, or earthquakes. They are still barely aware of the drastic consequences of global climate change. They would still rather argue about whether it is naturally or anthropogenically produced than prepare for the consequences.

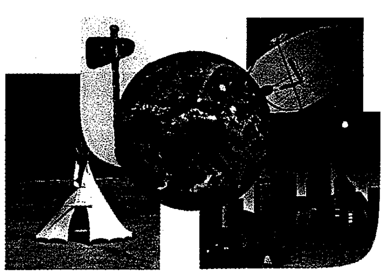

Figure 2 Humans have used Earth resources from prehistoric times to the present: the nature of the most sought after resources may have changed over time, but their importance for human survival and development has not.

The crucial pieces of knowledge that are commonly missing relate to the intimate connection between the Earth, its resources, and human civilization. If earth scientists don't emphasize and elaborate this connection, the relationship between the Earth and its residents may grow weaker. Citizens, especially city dwellers, tend to lose all intimacy with the Earth and forget that what they, and their ancestors, have constructed is composed entirely of materials extracted from the Earth. They then exacerbate this disconnection by holding views on the state of the environment that are completely incompatible with the rewards of civilization that they enjoy. They commonly hold views locally that are not sustainable on a national or global level. This has been referred to successively as the Nimby Syndrome (Not In My Back Yard) and, more recently, as the more extreme Banana Syndrome (Build Absolutely Nothing Anywhere Near Anybody). Because of a lack of knowledge they are unable to hold a balanced view of management of the Earth's resources and environment. It seems that nations with the greatest wealth, and therefore with the most voracious and sophisticated use of Earth resources, are the nations that are most disconnected. Canada is surely one of these.

REPAIRING THE CONNECTION BETWEEN PEOPLE AND EARTH RESOURCES

If you visit an elementary or junior high school class you can play a game with the students and their teachers in which they try to find something in the classroom that was not produced from the Earth. For example, the glass in the windows from quartz sand pits, the wallboard from gypsum mines, and the plastic chairs from hydrocarbons (Fig. 3). Many often think computers are different because they are part of the new clean information age and so it is important to point to the copper wiring, solder, silicon, steel, glass, and plastic of the computers. By the end of the game, there is nothing in the classroom, except the students themselves, that is not made from something extracted from a hole in the ground. Once this is established, you can easily reconnect them to their planet. This can be a revealing exercise for students and teachers alike. In my experience it is common to discover that a majority of people in an elementary classroom do not know, for example, that plastic is made from hydrocarbons or that metals are extracted from mines. The fact that much of this personal experience is based in Alberta, the home of the oil and gas industry in Canada, makes the lack of understanding particularly disturbing.

Another example might be local resistance to the opening of a gravel pit. It is common for the general public not to understand that deposits of any natural resource are localized and that the exploiter can't just move over the hill and mine the same resources. Again this is a fundamental piece of knowledge that seems self evident to earth scientists, but is often lost in public debate. If people have trouble understanding the distribution of resources at the Earth's surface, then consider how much more difficult it must be for them to develop an understanding of the distribution of resources that are out of sight underground, such as groundwater, oil, and gas.

Therefore I would urge any corporation, learned society, or government agency that wants to improve Canadians' knowledge of earth science to start at the very beginning by linking the Earth to the resources extracted from it.

REPAIRING THE CONNECTION BETWEEN PEOPLE AND EARTH PROCESSES

While it is encouraging that surveys show

Figure 3 It is common to discover that a majority of people in an elementary classroom do not know, for example, that plastic is made from hydrocarbons.

that a majority of Canadians are at least aware of the general existence of plate tectonics (Fig. 4), how does the process affect the majority of Canadians? It probably doesn't. It does affect those who live in the westernmost part of the country directly because of the risk of major earthquakes and volcanic eruptions. For the rest it is largely an interesting theoretical, but unobservable concept.

Something that many more Canadians may experience in a personal way has to do with their own interface with the surface of the Earth. First, they may experience landslides and have no idea of their cause, whether natural or anthropogenic. The first thing that may cross the mind of a motorist delayed by a landslide in the mountains is why the government allows this kind of thing to happen and why it didn't put up barriers to prevent this inconvenience.

On a more local scale, the public may fail to understand processes that affect their own property. Why do people continue to build on flood plains, on rapidly eroding cliffs, or on unstable rocks or soils (Fig. 5)? They seem surprised when their property slips downslope or becomes flooded and they expect society to do something about it. This shows a much more critical lack of understanding about their Earth than does a lack of understanding of diurnal or annual planetary cycles about which they may

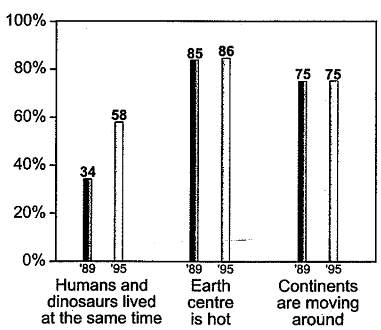

Figure 4 A graph representing the percentage of correct answers to questions in the two national surveys of Canadians: results from 1989 published in Einsiedel (1990) and for 1995 in a study commissioned by the Discovery Channel. With respect to the first question, the movie *Jurassic Park* came out between 1989 and 1995 and educated a lot of people.

have been tested during the science literacy survey.

This is not to say that knowledge of important earth processes like plate tectonics or planetary cycles is unimportant for people; it is just that we should take care to include other more immediate and basic earth science topics in our school curricula and in our outreach efforts to the public.

CONNECTING EARTH SCIENCES AND THE REGIONS OF CANADA

Everyone takes social studies (what used to be known as geography and history) in school, and one of the key components of those studies is a regional view of Canada. One of the most effective ways to get across the importance of earth sciences to students is to review the geographic regions of Canada for a social studies class using a geological map, rather than the more familiar political or topographic map of the country.

The regions of Canada are generally considered to be the Maritimes, the Canadian Shield, the Great Lakes, the Arctic, the Prairies, and the Cordillera. If an earth scientist recites these while looking at a geological map of Canada, he or she will quickly realize that the geographic regions are differentiated primarily by their geology, although that will never be a reason given in the social studies text book.

The mixed economy and rapidly changing scenery of the Maritimes are clearly rooted in the complex geology of the Appalachian orogen. It is the reason there are frozen french fry factories in one valley and a copper mine in the next.

The Canadian Shield is explicitly delimited by the reds and pinks of Precambrian rocks. An earth scientist can relate the lack of good soil to low levels of agriculture, the long and complex history of the rocks to the relatively high incidence of mines, and point to the likelihood that anyone who grew up on the Shield likely was born in a town whose economy was based on the extraction of Earth resources: wood or minerals.

The Prairies are clearly delimited by the wide swatch of green representing Mesozoic rocks. One can use this to connect to the monotony of the landscape, the excellent agricultural conditions, the oil and gas resources beneath, and the tourism developed around the magnificent dinosaur fossils. The establishment of these connections often astounds the listener.

The Cordillera on the west are clearly defined by the north-south trending patterns on the geological map. One can readily relate tourism to mountains, mining to orogenic processes, earthquakes and volcanoes to the active mountain building, and the mixed economy to the great geological diversity. Again, most Canadians do not make these simple connections.

DO WE MEASURE EARTH SCIENCE LITERACY PROPERLY?

When scientific literacy is measured in surveys around the world, the key questions asked are usually simple, straightforward questions on scientific knowledge (see for example, Einsiedel, 1990 and the 1995 National Science Literacy Survey for Canadian examples). In the field of earth sciences such questions include true or false responses to statements such as: "The centre of the Earth is very hot," "The continents are moving slowly about on the surface of the Earth," or "The earliest humans lived at the same time as dinosaurs." In addition, questions such as "How long does it take for the Earth to go around the sun?" are posed directly to the person being surveyed. Canadians answer these questions reasonably competently (Fig.4).

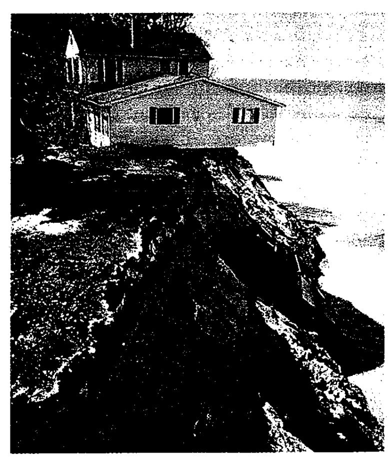

Figure 5 The public commonly fails to understand Earth processes that affect their own property.

While these questions do measure a certain kind of scientific knowledge, is it the kind of knowledge that we, as earth scientists, agree should be the *highest priority* knowledge for members of the general public? I don't think so. There is another whole level of knowledge that is much more fundamental for the public that is often overlooked and ignored because it is so self-evident to scientists themselves. However, such knowledge is often key to the possession of essential life skills and critical to decision making in the community.

In surveys, Canadians and citizens of other countries that want to have their populations measured for scientific literacy are asked what must seem almost hypothetical questions about the Earth with a right or wrong answer that can be measured. What is not measured is their understanding of the complex relationships between extraction of resources, their use and value, and their effect upon the general environment. Many also harbour misconceptions about natural hazards that may affect their lives from time to time. Furthermore, they commonly fail to understand much about their actual interface with the surface of the Earth on which they live. Think of the importance to humans of earthquakes, soil degradation, landslides, metals, plastics, and energy resources, and ask yourself what the general public knows about these.

GETTING THE MESSAGE OUT

As earth scientists, we have only ourselves to blame for the fact that North Americans are relatively unaware of the influence of Earth processes and Earth resources on their lives. We have tended to reach out by teaching the public the same things we teach our students in earth science departments. We believe that everyone should understand our science in exactly the same way that we understand it. In fact, we need to place a much stronger social context on earth science so that people can relate to it more easily. By the same token we often neglect to put a social context on the things we teach to our own earth science students, rendering them more ignorant than they should be about the social and ethical context for their work. We have commonly neglected to tell both the public and our students about the very simple connections between the Earth and our lives. There is cause for optimism in this area, however, especially with the production of posters under the Geoscape Project (Clague *et al.*, 1997) and a new series of posters on climate change (Clague and Turner, 2000). These simple communication tools provide the basis for more direct connections of earth sciences to everyday life. Another positive development is reflected in the publication of a book of essays by earth scientists that provide direct and accessible stories of Earth processes and human interaction with the Earth (Schneiderman, 2000).

Canadian agencies and corporations involved in earth sciences should renew, refocus, and redouble their outreach efforts. Any group that intends to go out and provide something to increase the public awareness of earth sciences should aim at making connections between the Earth and the economy, environment, and general well-being of the citizens of planet Earth. Don't aim too high, keep it simple and straightforward, and as far as possible put your explanations within the scope of activities of ordinary people.

ACKNOWLEDGMENTS

John Clague and Fran Haidl provided extremely helpful comments on an earlier version of this manuscript.

REFERENCES

Clague, J.J., Turner, R.J.W. and Groulx, B.J., 1997, Reinventing the geological map: Making science more accessible to Canadians: Geoscience Canada, v. 24, p. 161-172.

Clague, J.J. and Turner, R.J.W., 2000, Climate change in southwestern British Columbia: Extending the boundaries of earth science: Geoscience Canada, v. 27, p. 111-120.

Einsiedel, E.F., 1990, Scientific literacy: A Survey of Adult Canadians: Department of Communications, University of Calgary, 50 p.

Nowlan, G.S., 1998, The changing landscape of earth sciences in Canada: A story of erosion and uplift: Geoscience Canada, v. 49, p. 49-56.

Schneiderman, J.S., 2000, ed., The Earth Around Us: Maintaining a Livable Planet: W.H. Freeman and Company, New York, 455 p.

The 1995 National Science Literacy Survey, 1995, prepared for the Discovery Channel in collaboration with The Royal Society of Canada, the Ontario Science Centre and Science Network Ontario, 27 p.

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After reading the article "The Earth and its People: Repairing Broken Connections", make some notes so that you can discuss the following questions in class tomorrow:

1. What are some reasons why people seem to be losing touch with the earth?

2. Elaborate on why it is important for people to have an established connection to the earth and its environment.

3. What are some ways we can help repair the disconnection between the Earth and its people?

How did the Earth come to be?

Scientists use the Big Bang Theory to explain the origin of the modern universe. This theory states that a lot matter was created and spread throughout space in a giant explosion approximately 13.8 billion years ago.

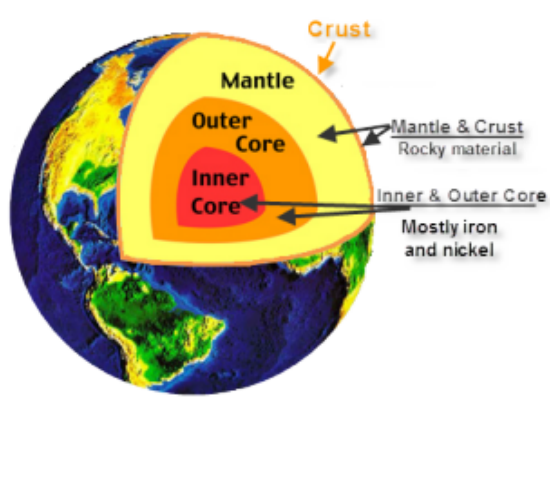
The Protoplanet Hypothesis is the explanation for how our solar system formed. It is believed that our sun was formed from a large cloud of gases and dust. Over time, the cloud was pulled inward due to its own gravitational force. The compressed matter created enough heat that hydrogen fusion began and the sun began giving off energy.

Leftover matter began to revolve around the sun by gravitational pull. Eventually this matter condensed into planets and other satellites such as moons which rotate within the solar system. Some smaller fragments still exist in our solar system as comets, meteorites, and asteroids.

The different compositions of planets is based on their proximity to the sun. Solar winds blew lighter elements to outer parts of the solar system, to become the outer planets (the gas giants). Heavier elements formed terrestrial planets closer to the sun.

When the Earth started to cool, more dense elements such as iron and nickel went to the centre and the less dense elements such as oxygen and silicon concentrated on the crust. Four distinct layers were formed, based on **chemical composition**:

- The crust, a thin layer (~50 km thick) made up of relatively light rock.
- The mantle, made of dense rock with lots of iron, magnesium and silicon (~2900 km thick)
- The outer core, made of liquid iron and nickel (~2250 km thick)
- The inner core, made of solid iron and nickel (~1300 km radius).



The earth's structure can also be classified by its physical rather than its chemical properties. The uppermost layer of the earth is composed of a series of rigid plates, known collectively as the **lithosphere**. It incorporates the crust as well as the upper part of the mantle, and is about 100 km thick. The rigid lithosphere floats on top of the more plastic part of the upper mantle, known as the **asthenosphere**, a layer approximately 700 km thick. Finally, at a depth of about 800 km below the Earth's surface, the mantle's density sharply increases, marking the division between the upper and lower mantle. That division marks the start of the **mesosphere**.

Water molecules were emitted during volcanic eruptions and in meteor impacts. It condensed as the Earth cooled and gathered in low-lying areas to form **oceans** and **lakes**. The water layer on the surface of the earth is known as the hydrosphere.

Surrounding our planet is a layer of gasses known as the **atmosphere**. The earliest atmosphere was formed from volcanic eruptions (such as water vapour, carbon dioxide, sulphur dioxide, methane). Later, organisms capable of **photosynthesis** (i.e., algae) consumed carbon dioxide and produced **oxygen**. Many other chemical reactions produced the ozone (O_3) and other gases that make up our current atmosphere.

The Earth has had a very dynamic past. The continents have moved around and many different eras and epochs of organisms have lived and become extinct. We will study these aspects of geology in detail over the course of the semester.

<u>Read pg. 13-15 in text, and answer the following questions:</u>

1. What is a solar nebula? Describe how it forms.

2. Define accretion and the role it plays in the formation of planetessimals.

3. What processes were necessary for the solar nebula to convert into our Sun?

4. How did Earth's early composition and density compare to modern Earth?

5. How did Earth's heating affect the Earth's composition?

6. What two elements are thought to make up most of the Earth's core?

7. Compare the densities of the core, mantle, and crust. What do you notice?

8. What material is believed to make up most of the mantle?

9. Which layer of the mantle makes up most of the Earth's volume?

10. What is the asthenosphere, and how does it differ from the lower mantle?

11. Describe the Earth's lithosphere.

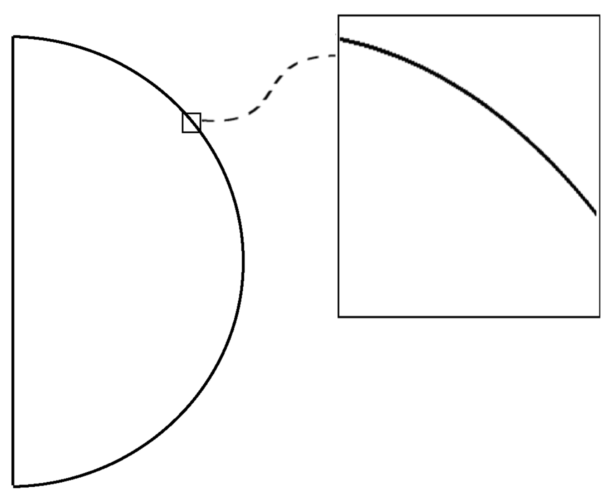
12. What process allows lithospheric plates to move?

<u>Assignment:</u> On a separate sheet of paper, complete and label a cross-sectional diagram of the Earth with the relative positions of:

a. The inner core, outer core, mantle and crust.
b. The atmosphere
c. The hydrosphere
d. The lithosphere, asthenosphere, and mesosphere.

Include a brief description of each layer.

Your final diagram should look something like this:



Surface Features of the Earth

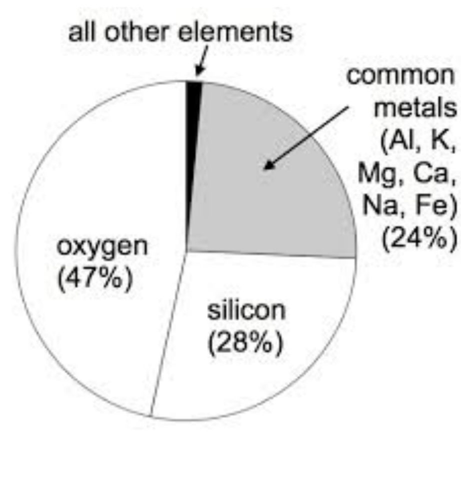
While the earth is often divided into layers based on composition (crust is lighter rock, mantle is more dense rock, and the core is iron and nickel), it can also be divided into layers based on the behaviour of the rock material. The outermost layer of the planet consists of brittle rock, broken into sections called plates. Together, these plates make up the lithosphere, and extend downwards from the surface of the earth, incorporating both the crust and the upper mantle. The rigid lithosphere floats on top of the more fluid asthenosphere (lower mantle), allowing individual plates to move about independently.

Plates are defined by the type of crustal material they contain – thin, oceanic crust or thicker continental crust. Oceanic crust consists of dense basaltic rocks high in iron while the continental crust consists of lighter granitic rocks higher in silicon. Although these plates move slowly, over the long time the Earth has existed huge distances can be covered as the landmasses move apart and collide with each other to form new patterns of land. About 30% of the crust is continental crust, forming the land, the other 70% is oceanic crust, forming the ocean basins.

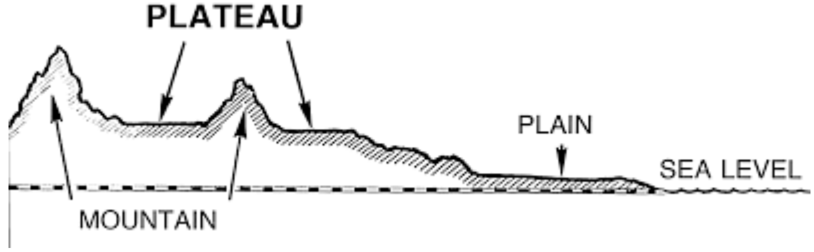
The average elevation on the continents is about 800 m above sea level. In many areas, however, the elevation is much higher than this. For example, Mt. Everest (the highest point on Earth), is 8 848 m above sea level. The top of the continental crust may also be below sea level - the shores of the Dead Sea, in the Middle East, are 392 m *below* sea level.

The ocean floor depth averages 4 800 m below sea level. The ocean is generally shallower closer to the continents, and deepest towards the middle of the oceans. The deepest point, however (the Marianas Trench found off the coast of Asia), is 11 022m below sea level.

Chemically, the Earth's crust is mostly oxygen (47%), silicon (28%), aluminum (8%), iron (5%) with the balance being a wide selection of other elements.



Continental Landforms



Some of the most important features of the land are:

1. **Mountains**
   Mountains are formed by a variety of processes such as:
   a) Folding and faulting – crumpling and uplift of land as continents get pushed against each other (Rocky Mountains, Himalayas)
   b) Pushing up of molten igneous rocks from below (BC Coast Range)
   c) Piling up of volcanic rocks on the surface (Mt. Garibaldi, Mt. Baker)

2. **Plains**
   These form when there has been no mountain building over a very long time period and parts of the continents are worn away by erosion. They can also form when large amounts of sediments are deposited over a long time period.

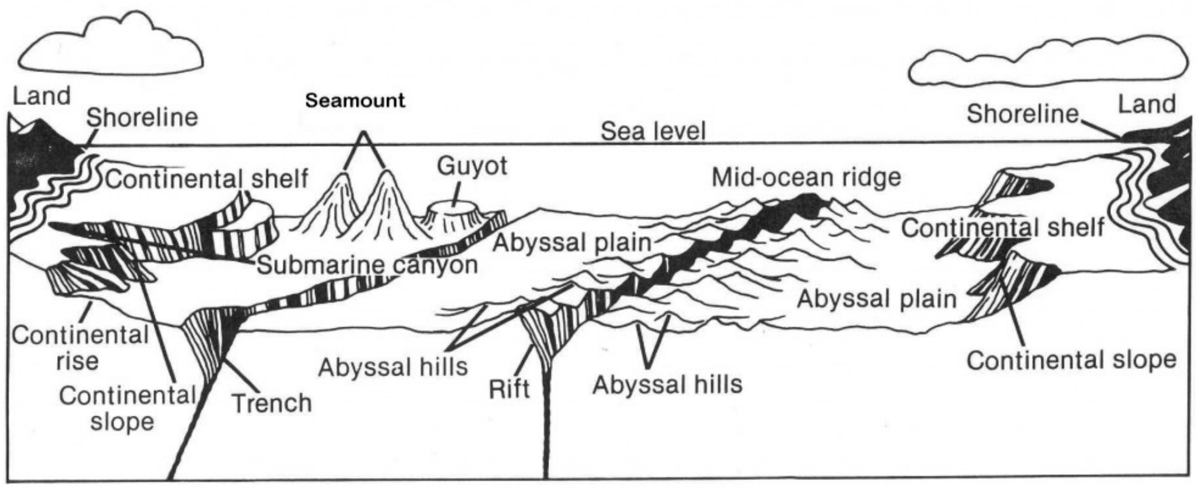
3. **Plateaus**
   Plateaus are formed by the uplift of large plains, or the buildup of lava flows as in the Fraser plateau north of Clinton. Many plateaus are made of flat layers of uplifted sedimentary rock, or volcanic rock. Others occur when highly folded rocks have the tops eroded so that they are now relatively flat as is the case with the Interior Plateau of British Columbia.

4. **Basins**
   These are low areas that are surrounded by mountains. Examples are the area around Prince George (the Fraser Basin), the Nass Basin between the Skeena and Hazelton Mountains, and the Straits of Georgia and surrounding land (the Georgia Basin).

5. **Valleys**
   Valleys are cut into the land by streams and rivers to form V-shaped valleys, or by glaciers that form U-shaped valleys.

Sea Bottom Landforms

Although we cannot see it directly, the bottom of the ocean is as varied as the land. The more important features are listed below, together with brief descriptions. Some will be covered in more detail in later topics.



1. **Continental Margin**

   This is the area bordering a continent. It is a transition zone from the continent to the deep sea floor. The Continental Margin has three parts – the Shelf, the Slope, and the Rise.

   a) **The Continental Shelf** is a very gentle slope down to approximately 200 m depth. The edge of the continental shelf is considered to be the true boundary of the continent.

   b) **The Continental Slope** leads off from the Shelf, and is somewhat steeper. Around North America it ranges in width from a few kilometres to over 300 km, and in depth from 1600 m to 3600 m.

   c) **The Continental Rise** is a very gentle slope from the base of the Slope to the deep sea floor. It is covered in sediment deposits which are several kilometres thick. The rise varies in width from a few kilometres to hundreds of kilometres.

2. Deep Sea Floor

The deep sea floor is made of relatively flat lava flows. It contains variable, isolated mountains and plateaus.

a) **Sea Mounts** are isolated mountains on the deep sea floor. Guyots are flat-topped seamounts. The tops of the original sea mounts are believed to have been eroded away when they were above sea level some time during their history.

b) **Mid-Ocean Ridge** is a very large mountain chain down the middle of the ocean floor. It is more than 65 000 km long and a few hundred kilometres wide. It ranges from 3000 m to 10 000 m in height from its base on the deep sea floor. The Ridge forms from the build-up of lava from the Earth's mantle.

c) **Deep Sea Trenches** are found next to continent, such as South America, or island chains such as Japan and Indonesia. The deepest goes down more than 11 000 m below sea level. You will learn more about the importance of mid-ocean ridges and deep sea trenches in relation to moving continents and mountain building in the Plate Tectonics unit.

Questions:

1. What are the two types of crust, and what is the relative percentage of each type?

2. List the four most common chemical elements found in the crust from greatest to smallest percentages.

3. Describe three ways mountains can form.

4. Differentiate between:
    a. A plain and a plateau

    b. A basin and a valley

    c. The continental shelf and the continental slope

5. Sketch a diagram of a continental margin and label the shelf, slope and rise.

6. Describe the mid-ocean ridge.

7. What is a guyot, and how does it form?

Continental and Oceanic Landforms

The ocean floor has an average depth of 4 km, or 13000 ft - but a lot of the ocean is deeper or shallower than that. In fact, the sea floor varies quite a bit in depth, with topographic features analogous to mountains and valleys on land.

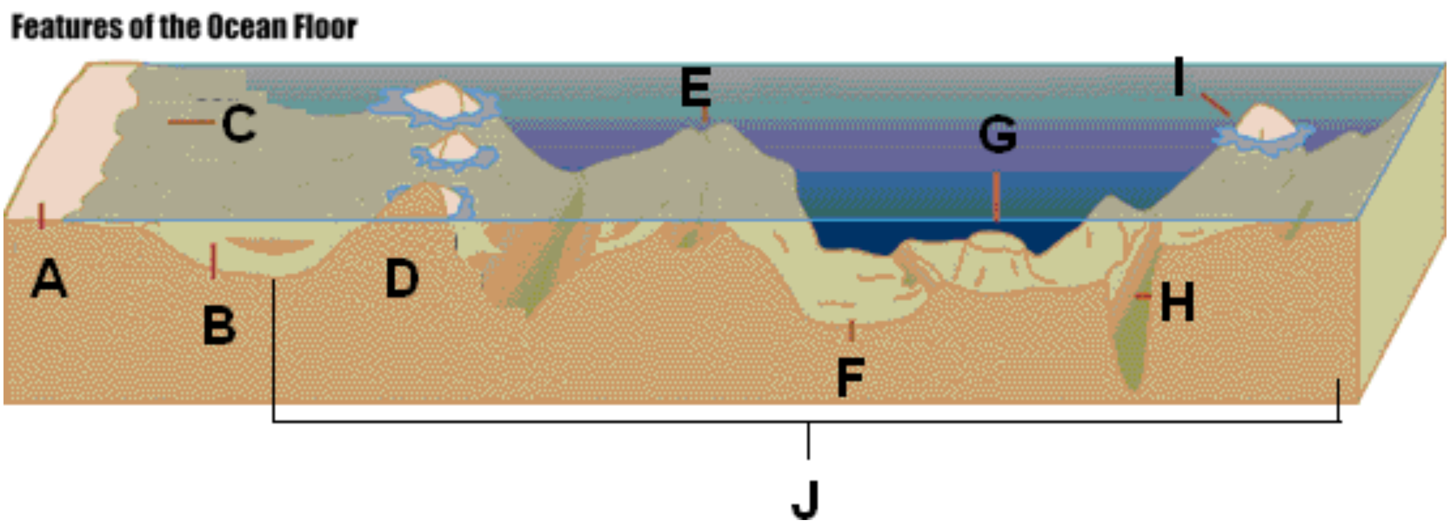
Around most continents are shallow seas that cover gently sloping areas called continental shelves. These reach depths of about 200 m. The continental shelves end at the steeper continental slopes, which lead down to the deepest parts of the ocean.

Beyond the continental slope is the abyss, where the depth falls to somewhere between 3 and 5 km. The abyss consists of flat regions called abyssal plains, which are interrupted with hills and mountains called seamounts.

Seamounts form where sediment has built up or submarine volcanoes exist. Some sea mounts are isolated, while others appear in chains called volcanic island arcs. Some sea mounts, called guyots, are extinct volcanoes with flat tops. Scientists think that these underwater mountains were once mountains, but their tops were worn away by waves.

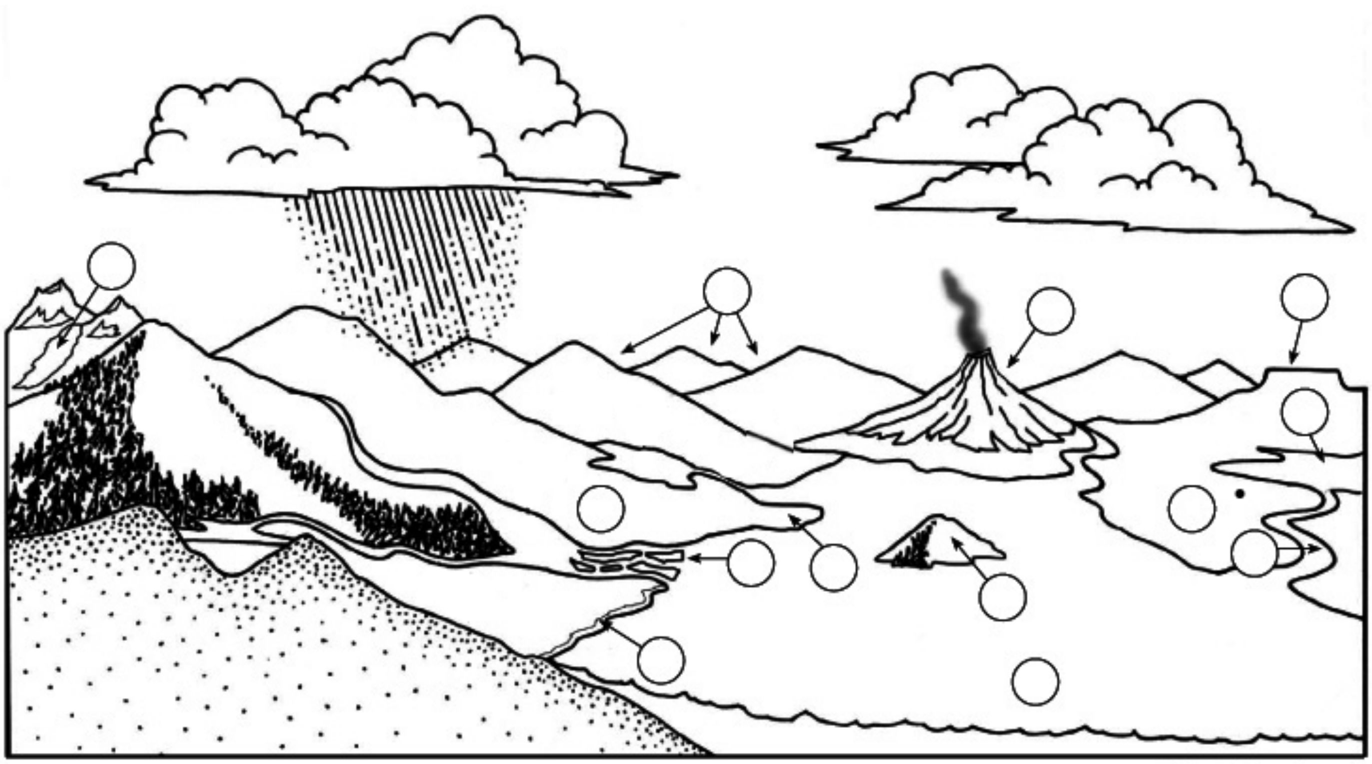
Far out in the middle of the oceans, there is a belt of elevated floor called the "mid-oceanic ridge." The depth here is between 2 and 4 km (6500 and 13000 ft).

The deepest parts of the ocean are deep-sea trenches, which are elongated trenches that run along the edge of certain continental shelves. The depth here can be from 5 to 12 km.



The figure above shows features of the ocean floor. Identify each feature by writing the correct letter in the spaces provided.

Abyss ____	Guyot ____
Abyssal Plain ____	Mid Ocean Ridge ____
Continent ____	Ocean trench ____
Continental Shelf ____	Seamount ____
Continental Slope ____	Volcanic Island Arc____



Add the correct number to each of the landforms and waterways shown above:

1. Beach	2. Delta	3. Island	4. Glacier
5. Lake	6. Mountains	7. Ocean	8. Peninsula
9. Plain	10. Plateau	11. River	12. Valley
13. Volcano			

1. True or False:

_______ 1. Only our planet has a lot of water.
_______ 2. The earth's water layer is called the atmosphere.
_______ 3. Plains are formed by the uplift of plateaus.
_______ 4. The continental shelf has a gentle slant.
_______ 5. The continental slope has a gentle slant.
_______ 6. Mountains may be formed from molten rock pushing up from below.
_______ 7. The deep sea floor starts at the beginning of the continental shelf.
_______ 8. A mid-ocean ridge is a high place on the ocean floor.
_______ 9. The Straits of Georgia are an example of a basin.
_______ 10. V-shaped valleys are formed when glaciers move down a mountain.

SURFACE FEATURES OF THE EARTH

In this activity, you will find the location of various types of landforms, and then mark these landforms on an outline map of the World using pencil crayons. As well as your textbook and the internet, you can refer to other maps posted around the room. Label all features neatly and clearly. **To prevent your map from becoming too cluttered, label each feature by its letter/number code.** For example, label the Rocky Mountains as **A1**. You will need to put a 'Key' along the bottom of your map.

NOTE: -This map will be needed for later parts of the course.

A. In **BROWN**, mark the following major **Mountain Ranges**: -

1. The Rocky Mountains
2. The BC Coast Range
3. The Appalachian Mountains
4. The Andes
5. The Alps
6. The Caucasus Mountains
7. The Ural Mountains
8. The Himilayas
9. The Great Dividing Range

B. With a **PENCIL CROSS**, mark the following prominent **Mountains**. On the back of the map, list the elevation (in metres) of each.

1. Aconcagua
2. El'brus
3. Kilimanjaro
4. Mont Blanc
5. Mt. Everest
6. Mt. Jaya
7. Mt. Koscuisko
8. Mt. Cook
9. Mt. Logan
10. Mt. McKinley
11. Mt. Robson

C. In **GREEN**, mark the following **Plains, Plateaus** and **Basins**: -

1. The Great Plains of North America
2. Great Lakes Basin
3. Amazon Basin
4. Brazilian Highlands
5. Argentine Pampas
6. Congo Basin
7. North European Plain
8. Central Siberian Plateau
9. West Siberian Plain
10. Tibetan Plateau
11. Lake Eyre Basin

D. Use a small **RED TRIANGLE**, mark the following **Volcanoes**:

1. Mt. Baker
2. Mt. St. Helens
3. Mt. Lassen
4. Popocatapetl
5. Cotopaxi
6. Aconcagua
7. Mt. Fuji
8. Krakatau
9. Mt. Ruapehu
10. Mauna Loa
11. Mt. Vesuvius
12. Hekla

E. Use a **BLUE LINE** to mark the following **Ocean Ridges**. These ocean ridges should all connect to make one continuous Ridge system. Label the following sections:

1. Juan de Fuca Ridge
2. Mid-Atlantic Ridge
3. Southwest Indian Ridge
4. Central Indian Ridge
5. Southeast Indian Ridge
6. Indian-Antarctic Ridge
7. Pacific-Antarctic Ridge
8. East Pacific Ridge/Rise
9. Chile Rise
10. Nasca Ridge
11. Cocos Ridge

Using a **RED LINE** mark the following **Deep Ocean Trenches**: -

1. Puerto Rico Trench
2. Peru-Chile Trench
3. Aleutian Trench
4. Kuril Trench
5. Japan Trench
6. Bonin-Marianas-Yap Trenches
7. Tonga-Kermadoc Trench
8. Java Trench
9. Philippine Trench

QUESTIONS: Attach a sheet to the back of your map, answering the following questions **<u>in full sentences.</u>**

1. What is the ratio of water to land on the Earth's surface?
2. On average, how many times deeper is the deep ocean floor below sea level than continents are above sea level?
3. What is the highest point of land on Earth? Name of the feature, together with the elevation in metres.
4. What is the lowest point of land on Earth? Name of the feature, together with the elevation in metres.
5. What is the deepest ocean trench? What is its depth?