Units 5 & 6 Workbook KEY
Answers to Section F: Earth Materials (Mineral, Rock and Energy Resources)

1. Explain how hydrothermal activity can produce ore deposits

   Ground water is able to dissolve certain metals. If the water is near a heat source such as any magma intrusion the water heats up, and when the water heats up it is able to dissolve more. The hot water is more corrosive and able to dissolve more minerals. The hot water solution rises up along fractures in the rock and cools. The metals then precipitate to form a hydrothermal vein.

2. Describe how simple geochemical or geophysical data can be used to locate mineral, rock, or petroleum deposits

   Locating mineral, rock or petroleum deposits is also known as prospecting. Techniques to do this have changed a lot over the years and technology has increased a geologist's ability to locate resources.

Geophysical data	
Changes in gravity	*Use to locate dense minerals*
Changes in magnetic field	*Use to locate magnetite*
Resistivity	*Current in the ground, sulphide minerals decrease current*
Seismic methods	*Used primarily for locating petroleum*
Radiometric methods	*Use for uranium ores*
Geochemistry data	
Samples taken from an area and analysed for certain elements and a map is plotted	

3. Describe the uses of mineral, rock, and energy resources of major economic importance in British Columbia, including:
   - chalcopyrite, galena, gold, sphalerite, molybdenite, gypsum, limestone

chalcopyrite	*copper ore*	*electrical wiring*
galena	*lead ore*	*batteries, soldering, paints*
gold		*electronics, jewelry*
sphalerite	*zinc ore*	*galvanizing, cars*
molybdenite	*molybdenum ore*	
gypsum		*plaster*
limestone		*fertilizer, cement*

   - construction materials, coal, oil and gas

     The principle use for these energy resources is burning for heating and cars etc.

4. Deduce the origin of an ore body or a mineral or petroleum resource from data and geologic descriptions of the deposit

Deposit	***Description and origin of ore, mineral or petroleum resource***
Pegmatite = hydrothermal vein	*Found as course grained rocks, sometimes with uncommon metals. Hot water dissolves minerals and rises through fractures. The water cools and the metals precipitate as crystals.*
Magmatic deposits	*Metals found throughout igneous rocks, if concentrated, will be mined. Formed by fractional crystallization. Crystals form and sink to the bottom of the magma chamber.*
Kimberlites	*The source for diamonds. A pipe like pluton that stretches down to the mantle. Diamonds are formed in the extremely hot and high pressure environment of the mantle and then forced up rapidly.*
Iron deposits in sedimentary rock	*Iron dissolves in water when there is no oxygen present. When oxygen does return the iron settles to the bottom. These deposits were formed in the very early history of the earth.*
Evaporite deposits	*Examples are halite and gypsum. When a body of seawater is trapped and dries up it leaves behind the material dissolved in the seawater.*
Placers	*Sedimentary deposits of a high concentration of a heavy metal, usually gold. A river that slows down will deposit its heaviest particles first.*
Fossil fuels	*Any fossil fuel and various grades of coal all formed from plant and animal life.*

5. Describe the sequence of events through which oil and natural gas are believed to form

   Organic matter is carried to the oceans and sinks to the bottom along with all the other sediment carried into the oceans. This organic rich mud is buried with many layers. Over time with enough pressure from new layers the mud turns to shale and the organic matter turns to petroleum. The shale is not permeable but over thousands of years the petroleum can be squeezed out to a layer of sandstone or limestone. Sandstone and limestone is permeable so the oil can move fast enough to be extracted for our use. In order for the oil to stay in the ground it must accumulate behind an oil trap or cap rock, an impermeable layer of rock, usually shale.

   Natural gas forms when oil is heated during burial.

6. Explain how a variety of factors (e.g., price, concentration, accessibility, size, and environmental considerations) determine whether or not it is economically feasible to extract a given occurrence of a mineral, rock, or energy resource

   It costs a lot of money to explore, extract and refine any mineral, rock or energy resource. No company will invest in a mine only to sell the resource at a price that is lower than all the costs incurred to explore, extract and refine the resource. Companies only invest in mines that are going to make money. They all do a feasibility study first to determine if the mine will be profitable.

   Yet, it is still risky to mine any resource. Market values change over time, both up and down. Extraction and refining methods may improve over time increasing the yield. However, environmental considerations must be addressed and public attitudes can change.

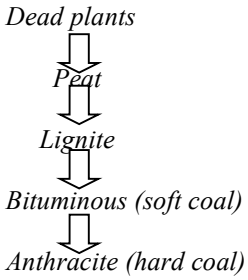
7. Explain the role of permeability and porosity in creating oil and gas reservoirs and traps

Oil and gas is able to move through all then spaces in a permeable rock. Oil and gas can be stored in porous rock, because there is space between all of the particles in that rock. Sandstone is both permeable and porous because it can hold oil and gas within the spaces between the particles and the oil and gas can move within the rock. Shale, however, is porous but no permeable. Oil and gas must be stored in porous rock but also with permeable rock, otherwise it would not flow with the rock to get it out. Sandstone serves as a reservoir for oil and gas. But to prevent the oil and gas from escaping to the surface it must be trapped by an impermeable layer of rock. Shale serves as a cap rock or trap from oil and gas.

8. Describe the sequence of stages in the formation of different grades of coal

Dead plants fall to the ground. As the plant layers accumulate the decomposition of the bottom layers stop. Partially decayed matter is called ***peat****. When the peat is compressed the water is squeezed out, and during burial the hydrogen and oxygen escapes as gases. The result is* ***coal****.*

Coal forms in environments in which plants grow and die rapidly such as swamps.



9. What are some important uses of minerals?

Minerals are used as rock-forming minerals, ores, or gemstones

10. What is an ore?

A mineral that can be economically mined for its metal

11. What is the chief source of iron? Zinc? Lead? Aluminum? Copper? Mercury?

Iron	*Hematite*
Zinc	*Sphalerite*
Lead	*Galena*
Aluminum	*Bauxite*
Copper	*Chalcopyrite*
Mercury	*Cinnabar*

12. Name some native elements that can be mined.

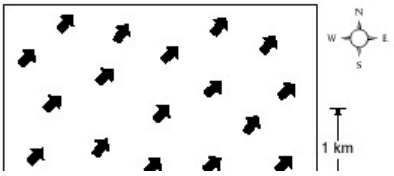
Copper
Gold
Silver
Platinum

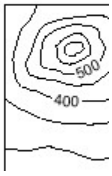
Use the following map of a flat, swampy area to answer questions 13 and 14.

13. Which of the following minerals is **most likely** to produce an anomaly of the type shown in the map?
    a) Quartz.
    b) Galena.
    c) Gypsum.
    d) Magnetite

The deposit would be a very dense mineral that can affect local gravity, but not affect the local magnetic field.

14. The **most likely** location on the map for an ore deposit is in the
    a) northeast quarter.
    b) southeast quarter.
    c) northwest quarter.
    d) southwest quarter.





15. Hydrothermal processes produce ore deposits by
    a) evenly distributing low concentration of heavy minerals throughout a host rock
    b) concentrating dense minerals in one area
    c) leaching out non-valuable minerals and leaving behind an enriched ore
    d) carrying dissolved metals into surrounding rocks, where they are precipitated out as ores in high concentration

16. Sampling water or stream sediments for high concentrations of particular metals is an example of which type of mineral exploration?
    a) geophysical methods
    b) remote sensing
    c) geochemical methods
    d) radioactivity methods

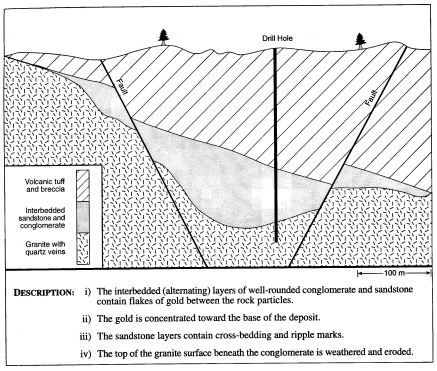
Use the following diagram and description of an ore deposit to answer questions 17 and 18.

17. The type of ore deposit is likely
    a) hydrothermal – vein.
    b) sedimentary – placer.
    c) sedimentary – marine evaporite.
    d) hydrothermal – sea floor hot spring.

The description describes a stream environment: conglomerate and sandstone, gold concentrated at the bottom, ripple marks and cross bedding. This is a buried river with placer deposits of gold.

18. The **most likely** *original* source of the gold in the deposit is the
    a) sandstone.
    b) conglomerate.
    c) volcanic tuff and breccia.
    d) granite with quartz veins.

A hydrothermal deposit of gold is the original source rock.



19. Which of the following is a common use for gold?
    a) Engine parts.
    b) Hardening steel.
    c) Electronic circuits.
    d) Electrical insulators.

20. Which of the following metals is commonly **concentrated** by weathering and erosion?
    a) Zinc
    b) Gold
    c) Lead
    d) Molybdenum

Gold is the most dense and easily settles to the bottom of any stream bed. Also gold is non-reactive.

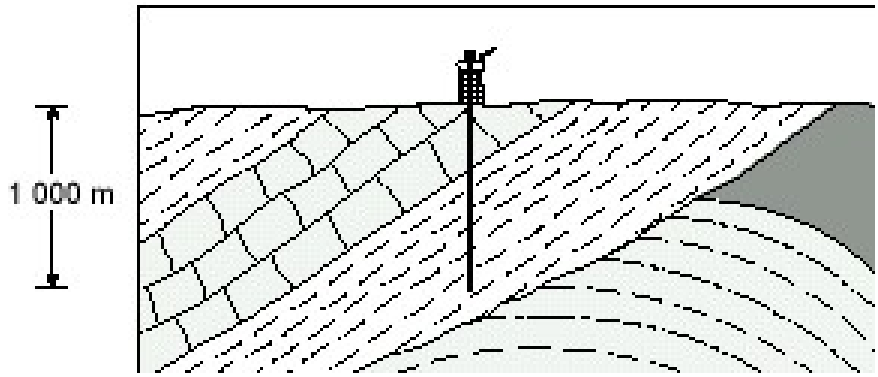
21. What kinds of rocks serve as source rocks for petroleum? In what kinds of rocks does petroleum tend to be trapped? Why?
    The source rock for petroleum is shale. Petroleum tends to be stored in sandstone or limestone because sandstone is porous but also permeable, it can be extract from permeable rock.

22. Which property of rock would best determine its ability to store hydrocarbons?
    a) Low porosity
    b) High porosity
    c) Low permeability
    d) High permeability

23. The following table shows four types of coal, with typical values for the percentage of carbon, hydrogen and oxygen in each. Which type of coal would have experienced the **greatest** degree of metamorphism?

	Type of Coal	% Carbon	%Hydrogen plus oxygen
a)	Lignite	60	36
b)	Sub-bituminous	70	27
c)	Bituminous	80	17
d)	Anthracite	90	8

Use the following diagram of a geological cross section to answer question 24

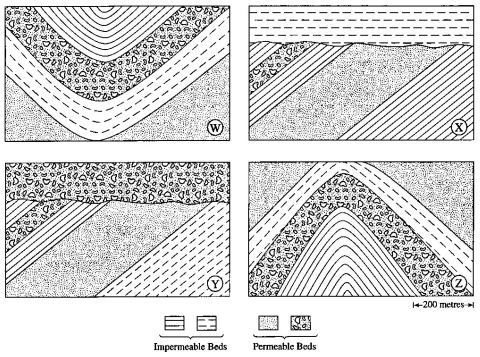


24. Referring to the cross section above, explain why this well would not produce oil. Name a more appropriate layer to drill to, and explain the reason for your choice.

    The well has been drilled down into the shale, an impermeable layer of rock. There may indeed be oil in this layer but it will not flow. A more appropriate layer to drill would be down to the layer of sandstone because here the rock is permeable and the oil can flow.

Use the following diagram of four geological cross sections to answer question 25

25. The two structures that could act as oil traps are
    a) W and Z
    b) X and Y
    c) W and Y
    d) X and Z



26. Which of the following fossil fuels involves the least

To extract natural gas a hole is drilled into the ground and the gas comes up under its own pressure. The other methods involve much large areas of land.

number of environmental problems during its extraction from the ground?

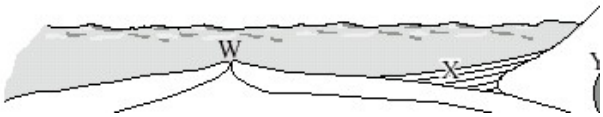
a) Coal
b) Tar sand
c) Oil shale
d) Natural Gas

Use the following diagram to answer question 27.

27. In which of the four locations on the cross section would you **least** expect to find a hydrothermal ore deposit?

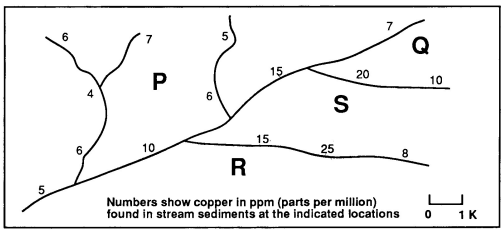
a) W
b) X
c) Y
d) Z

X is furthest from any heat source and furthest from any fractured rock.



28. The map shows concentrations of copper found in sediments along stream beds. Which letter most likely corresponds to the location of a potential ore deposit? Why.

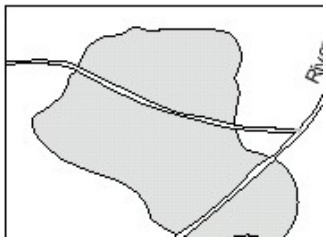
S because the concentrations in the rivers near location S are the highest.



29. A valuable mineral which is most likely to be found in the potential ore deposit is

a) pyrite
b) galena
c) sphalerite
d) chalcopyrite

Use the following sketch map to answer question 30.



30. The shaded area shown on the map represents fractured volcanic rock that has been intruded and altered by mineral veins. Exploration of the area has found concentrations of chalcopyrite, galena and sphalerite.

a) Name and describe the process **most likely** responsible for the formation of this deposit.

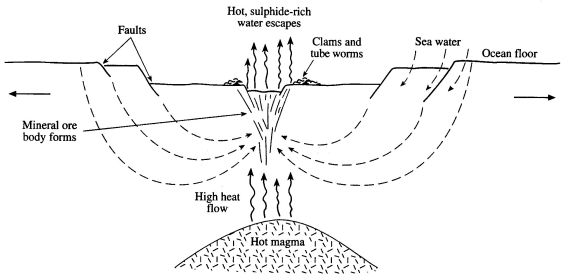
Name: *Hydrothermal deposition*

Description: *A hot, mineral and water-rich solution, possibly derived from a magma, that has intruded the volcanic rock along veins and has altered both the volcanic rock and deposited ore minerals, or description of vents / smokers.*

b) Describe **two** specific factors that must be considered before developing a mine in the area.

Is there sufficient ore to make mining worthwhile?
Is the river likely to flood mine workings?
Are the prices of the ore metals high enough to make mining worthwhile?
Is the mine close enough to a smelter (transport costs) to make mining worthwhile?
Concentration factor/ore grade.
Is there any possibility of the river being polluted during mining and milling activities?
Will there be any air pollution (dust/gases) that may affect the nearby town?
Other environmental factors.

Use the following diagram of a submarine "black smoker" hydrothermal vent to answer question 31.



31. New, large mineral deposits of copper, zinc, silver, etc. are forming today on the sea floor at sites of hydrothermal vents.
    a) Referring to the diagram above, describe why the vents are usually located in an oceanic rift valley.
    Sea floor spreading occurs at oceanic rift valleys. This is a volcanic area, and therefore there is an abundance of heat available to drive the water convection. The rock is heavily fractured and faulted, which provides channel ways for the water.

    b) Referring to the diagram above, describe a possible source for the metals in the hydrothermal solution.
    The most likely source for the metals in the hydrothermal solution is the rocks of the ocean crust through which the hot water travels. A less likely source is from the magma fluids.

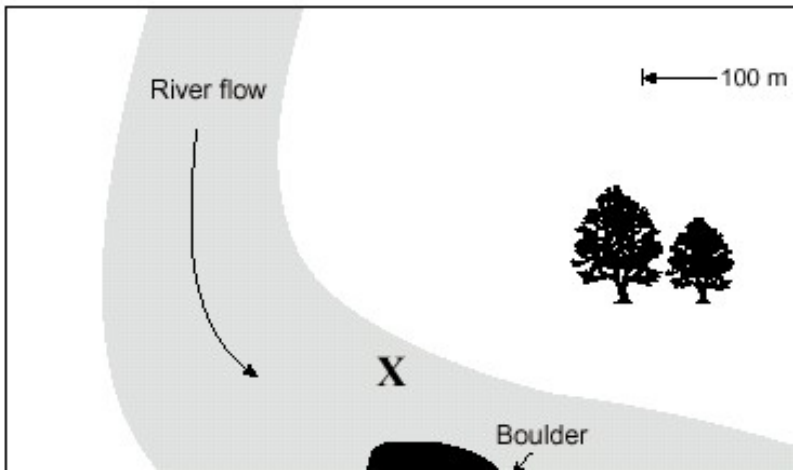
    c) Explain why the ore minerals are often deposited close to the hydrothermal vent.
    Ore minerals in the hot water solution precipitate quickly on contact with cool sea water. The solubility changes when they enter cold water.

    d) The black smoker is believed to contain valuable resource minerals. Give **two** examples of valuable minerals that may be found in this environment.
    Chalcopyrite (copper ore), Galena (lead ore), Sphalerite (zinc ore), Gold, Silver, Molybdenite Bornite.

    e) Explain why the location of the black smoker may make this type of mineral deposit economically impractical to exploit.
    If there were insufficient ore, it would not be economical to recover it.
    The difficulties encountered in extracting the ore from the ocean floor at a depth of 3 to 4 km may make it too expensive to recover.
    If the ore is too diluted with other, non-valuable materials (i.e., not concentrated enough), then it may not be economical to recover the ore from such depths.
    Environmental impact.
    Geopolitical problem, because many of these oceanic rifts are in international waters.

32. Place two X's on the diagram to indicate two different places where placer deposits might form. Give a clear geological explanation why you would expect to find a placer deposit of economic value at this particular location in the stream

Inside and slightly downstream of meander, or behind (downstream) the boulder. The velocity of water slows down on the inside bank of the meander or behind the boulder allowing heavier, valuable minerals to accumulate and deposit.



Describe a possible original source of the minerals in the placer deposit.

From a hydrothermal vein. Minerals weathered out of rock from upstream (i.e., stream's drainage basin). The minerals are then transported, deposited and concentrated (eroded).

33. B.C. is rich in mineral and energy resources. Oil, gas and coal are found in areas of the province separate and distinct from those areas where metal ores are found. Some of these areas are illustrated on the sketch map. Describe the general geology of B.C. that would cause this distribution of resources.

For the formation of the hydrothermal copper deposits, this area must have had igneous activity in the past. The ground water was heated and dissolved the copper, this solution moved up though faults and precipitated as copper ores. The copper would be found in igneous rocks.

For the oil and gas to form in those locations, at some time in the past there must have been sedimentary processes and organic activity. The oil and gas would be found in sedimentary rocks.