EARTH SYSTEMS 3209
GRADING STANDARDS
JUNE 2009

1. Pre-marking Appraisal:

The Earth Systems 3209 public examination had a good sampling of unit outcomes. The items were of reasonable length. All graphics were clearly drawn and properly labeled. There was an appropriate mixture of level 1, 2 and 3 items from the table of specifications.

2. Post Marking Report:

Marking Standard and Consistency:

A random sample of 16 examinations were obtained and graded by members of the marking board. Marks were assigned to each item and recorded on a separate sheet of paper. The 16 examinations were put back into the original stacks and were re-evaluated when they appeared during the marking process. Both marks were compared and if discrepancies existed the chief marker reviewed the grade with the appropriate marker. Overall, marks from the random sample and the re-evaluation process compared favourably.

The following adaptations were made to the multiple choice answer key based on statistical analysis throughout the marking process:

Item # 3: It was decided that the center dot could also indicate tree growth; therefore, (A) and (B) were accepted.

Item # 16: (A) was correct since the intent of the question was to show 3 cleavage planes visible for <u>one</u> mineral type. Yet, the question states "How many cleavage planes are <u>visible</u>?" As a result, (C) was accepted since 9 cleavage planes are visible.

Item # 33: Students would have a good knowledge that slate leads to gneiss, yet they would have limited exposure to the timeline for phyllite and schist. Hence, (C) and (D) were accepted.

Item # 40: While a student would have good knowledge that energy is multiplied by a factor of 30 (27 000), they would have very little exposure to amplitude which is multiplied by a factor of 10 (1000). Therefore, (C) and (D) were accepted.

Item # 47: The item was removed since sphalerite is a little know example as a source of Zinc.

Summary:

(A) Curriculum Outcomes

Student learning and assessment are based on the prescribed provincial curriculum outcomes. Several years ago, a number of prescribed curriculum outcomes were removed from the original Earth Systems 3209 Curriculum Guide. The changes made are posted on the Department's website at http://www.ed.gov.nl.ca/edu/k12/curriculum/guides/science/index.html#es3209 in the document referred to as "Revised Outcomes". This document lists the outcomes that were retained as part of the curriculum (a second document "removed outcomes" lists the topics/outcomes that were removed from the original guide).

It is important to note that while the "revised outcomes" document lists the outcomes that are to be taught, teachers should not depend solely on this document to ensure they are covering the entire curriculum which will be assessed on the public exam. Specifically, committees that construct the public exams draw the content for items from both column 1 (outcomes) and column 2 (suggestions for learning and teaching). As a result, if only the "revised outcomes" list is used important commentary on depth of treatment or other clarifications used by item-writing teams preparing the public exam each year may be overlooked by teachers and students. Conversely, if teachers use the original curriculum guide and do not realize that some outcomes have been deleted from the curriculum, then they are covering content that will not be assessed on the public exam; consequently, they have less time to address those outcomes which may appear on the exam.

(B) Importance of Core Labs

Students in Earth System's should complete all twelve of the core laboratories embedded in the curriculum guide for the course since items spanning all levels of cognition are assessed on the public examination. A number of prescribed curriculum outcomes are addressed in theses labs.

(C) Levels of Assessment

Students should be aware that items on the public examination are assessed at three levels. At the higher levels they are required to analyze, apply, evaluate, and/or synthesize their knowledge. It is, therefore, important that opportunities are provided for students to practice these thinking skills.

(D) Attempting all Questions

It was noted by the markers that **many** students received zero percent on the constructed response items because they did not attempt an answer. Students should be aware that partial marks can be attained in their answers.

PART II
TOTAL VALUE: 40 %

CONSTRUCTED RESPONSE ANSWERS/COMMON ERRORS/COMMENTARY

Value
2%

61. (a) Recently a mummified human was found in Greenland. Radiometric analysis found that 6.25 % of the original carbon-14 remains. How old is the mummy? (half-life of carbon-14 = 5730 years). Show calculations.

Answer:

NOTE: The answer to this item can be found using various methods. One possible method and solution is outlined below:

A. Number of Half-lives that have taken place when 6.25 % of the original carbon-14 remains:

Parent Isotopes	:	Daughter Isotopes	
100 %	:	0 %	
50 %	:	50 %	= 1 Half-life
25 %	:	75 %	= 2 Half-lives
12.5 %	:	87.5 %	= 3 Half-lives
<u>6.25 %</u>	:	<u>93.75 %</u>	= <u>4 Half-lives</u>

B. Age of the mummified human:

5730 years (given half-life of carbon-14) X 4 half-lives = 22, 920 years

Mark Distribution:

1 mark for showing how the half-life was found.

0.5 mark was awarded if the process of radioactive decay was correctly demonstrated, but the number of half-lives was incorrect.

1 mark for showing how the age of the mummified human was found.

Common Errors and Commentary:

- Some students selected 5, as opposed to 4, as the number of half-lives that had occurred in order for 6.25 % of the original carbon-14 atoms to be remaining. They accepted a ratio of 100 % : 0 % to represent 1 half-life. Following on from this error, a ratio of 6.25 % : 93.75 % would represent 5 half-lives. Multiplying 5 by 5730 would equal 28, 650 years.

- Some students selected 3, as opposed to 4, as the number of half-lives that had occurred in order for 6.25 % of the original carbon-14 atoms to be remaining. They accepted a ratio of 50 % : 50 % to represent 0 half-lives. Following on from this error, a ratio of 6.25 % : 93.75 % would represent 3 half-lives. Multiplying 3 by 5730 would equal 17, 190 years.

- After correctly determining 4 half-lives, some students divided 5730 years by ½. The students continued to divide the result of the division calculations by ½ on three more occasions resulting in a final incorrect answer of 358 .125 years.

- Some students took the half-life of carbon-14, which is 5730 years, and divided it by 6.25, which is the percentage of the original carbon-14 (i.e. parent isotopes) remaining. This resulted in an incorrect final answer of 916.8.

Value
2 %

61. (b) A rock sample collected in the early 1950s was radiometrically age-dated at 3.5 billion years old using uranium/lead isotopes. The sample containers at that time were sealed with lead. Recently, rocks from the same outcrop were radiometrically age-dated at 2.8 billion years. Explain why the 1950s sample was dated incorrectly.

Answer:

Uranium (unstable parent isotopes) radioactively decays to lead (stable daughter isotopes). The ratio of parent isotopes to daughter isotopes is used to determine the number of half-lives that have taken place. Since the rock sample that was collected in the 1950s was placed in a container that was sealed with lead, the percentage of daughter isotopes appeared higher since lead isotopes from the seal was added to the lead isotopes in the rock sample. An incorrect ratio of parent isotopes to daughter isotopes (lesser parent isotopes and greater daughter isotopes) suggested that the number of half-lives that had taken place was higher. As a result, the known half-life of uranium to lead was multiplied by a larger number, which resulted in the age of the rock sample being higher.

Mark Distribution:

1 mark for explaining that the ratio of parent isotopes to daughter isotopes was incorrect since lead isotopes from the seal used on the 1950s container were added to the lead isotopes in the rock sample.

1 mark for explaining that an incorrect ratio would indicate an incorrect number of half-lives, which would also indicate an incorrect age for the rock sample.

Common Errors and Commentary:

- Some students suggested that a lead seal on the container served to contaminate the rock sample; however, they did not explain that such contamination (i.e. the addition of lead) altered the number of daughter isotopes in the ratio of parent isotopes to daughter isotopes, thereby indicating a higher number of half-lives.

- Some students indicated that lead was a parent isotope as opposed to a daughter isotope.

- Some students suggested that carbon-14 dating would have been a more appropriate choice. Some students claimed that using uranium/lead isotopes represented an inappropriate choice since carbon-14 dating, which was newer and perhaps more familiar, was available for use. Furthermore, some students claimed that by using carbon-14 dating, there would be no issue with lead contamination of the rock sample.

Value
2 %

62. (a) There is no evidence to suggest that Pluto ever melted. How would its interior structure differ from that of Earth?

Answer:

NOTE: Indicating either what did happen to Earth or what did not happen to Pluto in terms of both melting and segregation/differentiation into layers pose equally valid responses.

No melting of Pluto's interior due to heat from radioactive decay, heat from accretion, and heat from gravitational forces (i.e. the sources of heat that were responsible for the melting of Earth's interior) would suggest that no segregation/differentiation took place. Segregation/differentiation is the process of high density elements and/or minerals sinking towards the inside of a planet and low density elements and/or minerals rising towards the outside (or surface) of a planet. Since the interior of Pluto was not melted and since segregation/differentiation was unable to occur, the formation of layers inside of Pluto was not possible. Pluto is simply a large, solid, and unorganized mass of elements and/or minerals.

Mark Distribution:

1 mark for indicating that the process of segregation/differentiation was unable to occur in Pluto's interior since there was no melting. No melting occurred since there were not any sufficient sources of heat.

1 mark for indicating that distinct layers could not be formed in Pluto's interior since there was no segregation/differentiation.

Common Errors and Commentary:

- Some students neglected to comment on the interior of Pluto. Instead, they contrasted Pluto and Earth in relation to such spheres as hydrosphere, atmosphere, and biosphere. It was recognized that despite Earth possessing a hydrosphere, atmosphere, and biosphere, Pluto did not possess either of the spheres.

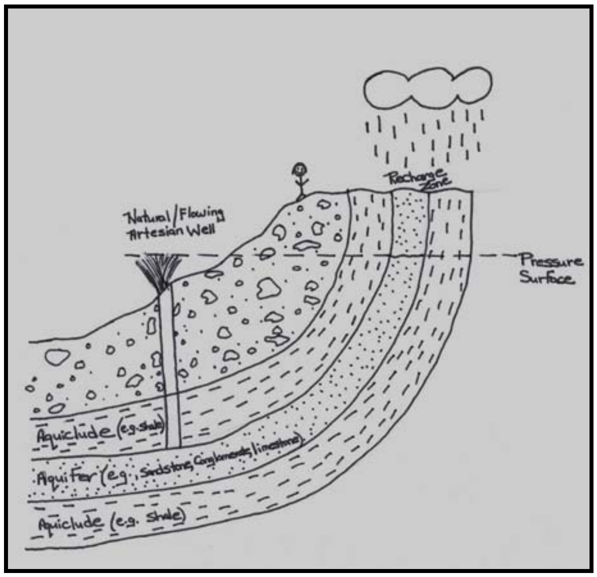
- Some students did not mention the process of segregation/differentiation that occurred in the Earth's interior, but did not occur in Pluto's interior.

- Some students did not contrast the interior structures of Earth and Pluto. Some students simply did not mention that the interior structure of Earth consisted of layers (e.g., inner core, outer core, mantle, and lithosphere), whereas the interior structure of Pluto is simply a solid and unorganized mass of matter (i.e. elements and/or minerals).

Value
2 %

62. (b) With reference to porosity and permeability, sketch and describe a natural artesian system.

Answer:



There must be an aquifer that is inclined and positioned between two aquicludes (or aquitards) that are also inclined. An aquifer could be described as being a water-open zone of rock since it is both porous (able to store water) and permeable (able to transmit water). One aquiclude must be positioned above the aquifer and the other must be positioned below the aquifer. An aquiclude is a water-closed zone of rock that may or may not be porous (able or unable to store water), but is definitely impermeable (unable to transmit water). A pressure gradient must exist inside the aquifer. A pressure gradient is the pressure difference that exists between the water table (or highest level) in the aquifer and the point where water is struck in the aquifer by a drill bit.

Mark Distribution:

1 mark for sketching a natural artesian system and properly labeling all of the parts. The presence of two aquicludes and one aquifer warranted 0.5 marks and the presence of a pressure gradient warranted 0.5 marks.

0.5 mark for describing the characteristics of an aquifer such as porosity, permeability, and shape.

0.5 mark for describing the characteristics of an aquiclude such as porosity, permeability, and shape.

Common Errors and Commentary:

- Some students failed to produce a natural artesian system in their drawings. Instead, they produced a well that was simply drilled or dug down into a zone of saturation (i.e. a water-filled zone of sedimentary rock) that was often not inclined.
- Some students omitted either all or some of the following components: aquifer, aquiclude (or aquitard); and water table (or pressure surface).
- Some students explained the terms porosity and permeability; however, they neglected to relate the terms to both aquifers and aquicludes (or aquitards), which are two components of a natural artesian system.

Value
2 %

63. (a) Explain why there would be a difference in crystal size between a plutonic intrusion with a 1 kilometre diameter and a plutonic intrusion with a 10 metre diameter.

Answer:

A plutonic intrusion that is 10 meters in diameter will cool relatively quickly, despite the fact that the magma is located underneath Earth's surface. Additionally, since the diameter is relatively small, heat from the interior of the plutonic intrusion will be loss quickly. Relatively quick cooling will not result in much time for crystals to grow large. As a result, smaller/finer crystals will be grown. A plutonic intrusion that is 1 kilometer in diameter will cool relatively slowly, particularly towards the interior since heat will be retained much longer there. Relatively slow cooling will result in much more time for crystals to grow large. As a result, larger/coarser crystals will be grown.

Mark Distribution:

1 mark for explaining why the intrusion with a 1 kilometer diameter will result in larger/coarser crystals. Greater ability to retain heat allows for more time for crystals to grow large.

1 mark for explaining why the intrusion with a 10 meter diameter will result in smaller/finer crystals. Diminished ability to retain heat allows for less time for crystals to grow large.

Common Errors and Commentary:

- Many students did not recognize that the diameter of one plutonic intrusion was measured in kilometers, whereas the other plutonic intrusion was measured in meters. These students rapidly made conclusions about cooling rates and crystal sizes based on the fact that 10 was a larger number than 1. They incorrectly concluded that the plutonic intrusion with a diameter of 10 meters retained its heat for a longer time span resulting in slower cooling and therefore, larger crystals. They also incorrectly concluded that the plutonic intrusion with a diameter of 1 kilometer retained its heat for a shorter time span resulting in faster cooling and therefore, smaller crystals.

- Some students confused cooling rates and resulting crystal sizes. For example, a slowly cooling plutonic intrusion results in small (or fine) crystals. As an additional example, a rapidly cooling plutonic intrusion results in large (or coarse) crystals.

- Some students mentioned that the plutonic intrusion with a 1 kilometer diameter possessed a larger surface area and as a result, the heat was greatly dispersed. This caused the plutonic intrusion to cool rapidly, thereby resulting in small (or fine) crystals. Some students mentioned that the plutonic intrusion with a 10 meter diameter possessed a smaller surface area and as a result, the heat was greatly concentrated. This caused the plutonic intrusion to cool slowly, thereby resulting in large (or coarse) crystals.

Value
2 %

63. (b) With reference to the diagram, explain why the two different sedimentary rocks developed in the areas indicated.

Answer:

It is evident from the diagram that the current direction is from left to right. Velocity of the current decreases with progression from left to right. It is this decrease in the velocity of the current that that causes the sediment particles to be horizontally sorted. The coarse/large sediment particles are deposited closest to the sources of weathering and are lithified to form the sedimentary rock called conglomerate. The fine/small sediment particles are deposited furthest from the sources of weathering and are lithified to form the sedimentary rock called shale.

Mark Distribution:

1 mark for explaining that horizontal sorting of sediment particles is caused by a decrease in the velocity of the current.

1 mark for making the connections between the rock types formed in both locations, the sizes of the comprising sediment particles in both locations, and their proximities from the sources of weathering.

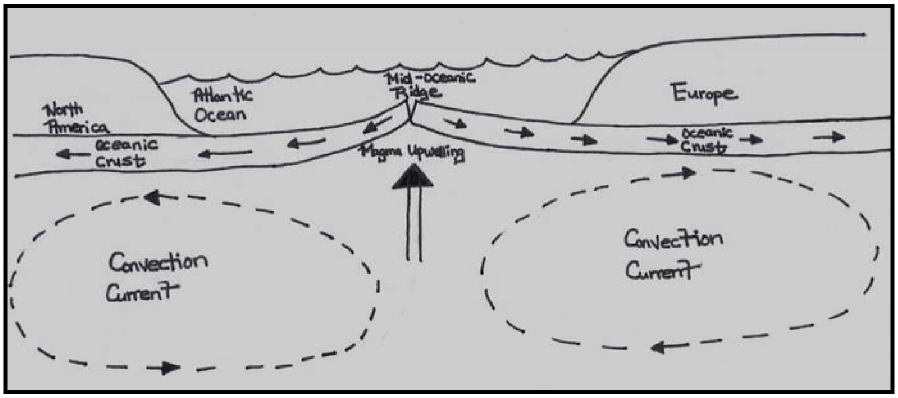
Common Errors and Commentary:

- Several students did not attribute the horizontal sorting of sediment particles to a decrease in the velocity of the current.
- Some students did not recognize that the sedimentary rocks were submerged under water. To the contrary, some students thought that it was a hill environment and gravity or some other agent (e.g. glacier) had eroded the sediment particles down the hillside breaking it up into smaller and smaller pieces with progression to the right.
- Some students concluded that because the shale was situated beneath a higher column of water, more compaction (i.e. pressure) was required for it to form (or lithify). Since the conglomerate was situated beneath a lower column of water, less compaction (i.e. pressure) was required for it to form (or lithify).
- Some students concluded that it was a shoreline environment that was characterized by intense and frequent wave activity. This activity served to disintegrate the rocks and transport the larger sediment particles landward and the smaller sediment particles seaward.

Value
3 %

63. (c) (i) Sketch and label a cross-section of the oceanic crust between North America and Europe.*

(ii) Explain why the continents are moving.



Answer:

Convection currents in the upper mantle (asthenosphere) are responsible for moving the North American Plate and the Eurasian Plate in opposite directions. It is the convection currents that exert tensional forces on both plates. A divergent boundary exists between the two plates that hosts the characteristic feature called a ridge, which is where mantle upwelling occurs that results in new oceanic crust being created and therefore, seafloor spreading occurring.

Mark Distribution:

1 mark for sketching and labeling a cross-section of the oceanic crust between North America and Europe. 0.5 mark was allotted for sketching and labeling oceanic crust and 0.5 mark was allotted for sketching and labeling the mid-oceanic ridge.

1 mark for indicating that convection currents in the upper mantle (asthenosphere) are responsible for the moving continents.

1 mark for indicating that mantle upwelling occurs at ridges along divergent boundaries, which results in seafloor spreading.

Common Errors and Commentary:

- Some students commented that continental drift explained why the continents (i.e. North America and Europe) were moving. These students failed to realize that a paradigm shift has occurred from accepting the Theory of Continental Drift to accepting the Theory of Plate Tectonics to explain moving continents and/or plates.

- Some students correctly commented that the Theory of Plate Tectonics explains why the continents (or plates) are moving; however, they failed to mention the mechanism (e.g. convection currents) that drives the movement of continents (or plates).

- Some students falsely indicated that a convergent plate boundary exists between North America and Europe. Some students even indicated that the process of subduction occurs along the boundary. Such a boundary involved the coming together of plates due to compressional forces, which is opposite to what is actually occurring in this area.

- Many students attributed the moving continents to the polarity of the oceanic crust forming at the Mid-oceanic Ridge. If the polarity of the oceanic crust forming at the ridge was normal, then students commented that the two continents would converge (i.e. move together). If the polarity of the oceanic crust at the ridge was reverse, then students commented that the two continents would diverge (i.e. move apart).

* Markers did not penalize students for misunderstanding the concept of cross section. The question was marked on all papers, but was not used in determining a student's mark if it was to the student's detriment.

Value
3 %

63. (d) Satellite imaging reveals a new volcano growing in the middle of the Australian-Indian Plate. *

(i) What type of volcano is forming in the middle of this crustal plate?

(ii) Explain how a volcano may have formed in this region.

Answer:

Since the volcano is growing in the middle of the Australian-Indian Plate, intraplate volcanism must be occurring. Shield volcanoes form from intraplate volcanism. This type of volcanism is caused by hotspots, which are stationary locations of molten upwelling in the mantle. As crustal plates move over hotspots, the molten that is upwelling burns or melts through the overlying crust forming shield (or hotspot) volcanoes. The lava that exits volcanoes at these locations has a low viscosity, which allows it to flow a far distance away from the vents of the volcanoes. This explains why shield volcanoes are often characterized as being broad, low in terms of height, and low in terms of slope. Basalt is the rock that often results from lava (on the surface) that exits shield volcanoes. Gabbro is the rock that often results from magma (underneath the surface) that cools slowly in magma chambers beneath shield volcanoes.

Mark Distribution:

1 mark for indicating that a shield (or hotspot) volcano is the type of volcano that is forming in the middle of the crustal plate.

1 mark for making the connection between intraplate volcanism (i.e. volcanism in the middle of a plate) and stationary hotspots in the mantle.

1 mark for explaining that shield (or hotspot) volcanoes form as a result of the molten upwelling and burning or melting through the overlying crust.

* Many students failed to make the connection between "middle" and a shield volcano formed by a hot spot and gave an explanation of an Island Arc volcano. The question was marked on all papers, but was not used in determining a student's mark if it was to the student's detriment.

Value
2 %

63. (e) Describe two possible effects of increased volcanic activity on Earth's climate.

Answer:

Volcanoes eject an abundance of material (e.g. dust) into the atmosphere upon eruption. Such material is moved through the atmosphere by Earth's prevailing winds. Solar radiation from the sun often reflects off such material back into space, thereby limiting the total amount of solar radiation that strikes Earth's surface. This results in a cooling climate on Earth. This type of climate becomes more significant as volcanic activity on Earth increases in frequency. Volcanoes eject gases such as carbon dioxide and water vapour into the atmosphere upon eruption. Such gases are referred to as greenhouse gases (GHGs), which actively serve to trap solar radiation from reflecting off Earth's surface back into outer space. This results in a warming climate on Earth. This type of climate becomes more significant as volcanic activity on Earth increases in frequency.

Mark Distribution:

1 mark for explaining why material (e.g. dust) ejected from a large number of volcanoes results in a cooling climate on Earth.

1 mark for explaining why greenhouse gases (e.g., carbon dioxide, water vapour) ejected from a large number of volcanoes results in a warming climate on Earth.

Common Errors and Commentary:

- Some students suggested that volcanic outgassing is occurring; however, they are failed to make the connection between the type of gases being emitted and the relationship to a warming climate. For example, carbon dioxide and water vapour are GHGs which are emitted from volcanoes and serve to trap outgoing solar radiation, thereby warming Earth's climate.

- Some students suggested that plant life is adversely affected by volcanic outgassing thereby, affecting food webs. Fewer plants means less photosynthesis; however, students did not indicate that less photosynthesis means there is more carbon dioxide in the atmosphere to trap outgoing solar radiation, thereby causing Earth's climate to warm.

- Some students commented that the heat released from volcanoes resulted in the warming of the atmosphere. Despite this being correct, the warming would be rather localized as opposed to being global. Short-term atmospheric conditions (i.e. weather) would certainly be greatly impacted; however, long-term atmospheric conditions (i.e. climate) would not be as greatly impacted.

Value
2 %

63. (f) Which of the unconformities would you expect to form in a mountain-building area? Support your choice.

Answer:

An angular unconformity is the type of unconformity that is expected in a mountain-building area. In the diagram, the layers beneath the angular unconformity are tilted and/or folded (i.e. uplifted), which indicates that slow and continual compressional forces were occurring. Such forces are associated with the process of mountain building. Once the layers were tilted and/or folded (i.e. uplifted), they were subjected to weathering and erosion that resulted in a time gap (i.e. loss of time) in the rock record.

Mark Distribution:

1 mark for indicating that an angular unconformity, as opposed to a disconformity, is expected in a mountain building area.

1 mark for making the connection between the tilted and/or folded (i.e. uplifted) layers beneath the angular unconformity in the diagram and the compressional forces that are required to deform them. Such forces are associated with the process of mountain building.

Common Errors and Commentary:

- Some students neglected to mention that the tilting and/or folding of the sedimentary layers beneath the angular unconformity was caused by orogenesis (i.e. mountain building). Some students simply did not mention that compressional forces, which are associated with mountain building, were required to deform (tilt and/or fold) the sedimentary layers from their original, horizontal positions.

- Some students incorrectly interpreted the disconformity (i.e. erosional surface) as a folded surface, thereby concluding that it was formed in a mountain-building area.

Value
4 %

63. (g) Use the diagram to answer questions (i) and (ii).

(i) Arrange all letters in the diagram above in the order in which they occurred beginning with the oldest.

(ii) Does A represent an intrusive feature or extrusive feature? Explain.

Answer:

Oldest ──────────────────────► Youngest

B C H G F D E J I A

A represents an intrusive feature as opposed to an extrusive feature. It intruded between layers **J** and **I**. The heat from the intrusion served to baked or metamorphose layers **J** and **I** along their contacts with the intrusion. This is known since multiple **X** symbols are evident in layer **I**, which is above the intrusion, and layer **J**, which is below the intrusion. The symbol **X** represents contact metamorphism or baking. It could only be an extrusion if multiple **X** symbols were not evident in layer **I**; however, evident in layer **J**.

Mark Distribution:

2 marks for correctly arranging all letters in the diagram in the order in which they occurred beginning with the oldest. Correctly arranging **B**, **C** (from oldest to youngest) warranted 0.5 marks, correctly arranging **H**, **G**, **F** (from oldest to youngest) warranted 0.5 marks, correctly arranging **D**, **E** (from oldest to youngest) warranted 0.5 marks, and correctly arranging **J**, **I**, **A** (from oldest to youngest) warranted 0.5 marks.

1 mark for indicating that **A** represents an intrusive feature as opposed to an extrusive feature.

1 mark for explaining how the contact metamorphism (or baking) that is evident above and below the intrusion in layers **I** and **J** proves that **A** is an intrusive feature.

Common Errors and Commentary:

- Students sometimes arranged the letters as **J**, **A**, **I** as opposed to **J**, **I**, **A** since they failed to recognize that contact metamorphism below and above **A** means that it is an intrusive feature as opposed to an extrusive feature.

- Some students suggested that **A** was an intrusive feature since it did not flow out onto Earth's surface. Despite this being correct, they failed to explain that it is an intrusive feature because of the existence of contact metamorphism below and above **A** in layers **J** and **I**. Note that 0.5 marks were awarded to students if they indicated that feature **A** was the youngest in the diagram.

- Some students suggested that **A** was an intrusive feature since layer **J** (i.e. below) and layer **I** (i.e. above) was melted by the released heat. However, melting does not occur during the formation of metamorphic rocks. To the contrary, it is hot chemical fluids such as water that combines with heat and pressure to metamorphose rocks.

Value
3 %

63. (h) Indicate the type of mineral deposit which could form at location A and explain the process. *

Answer:

Hydrothermal (or vein) is the type of mineral deposit that could form at location A. Pressure from the magma intrusion causes fractures or cracks to form in the overlying sedimentary rock layers. Ground water in the overlying sedimentary rock layers is warmed by the heat that is radiating out from the magma intrusion. Warm water can dissolve large quantities of elements. As the warm water, which is enriched in elements, flows toward Earth's surface (away from the magma intrusion) through fractures or cracks, it begins to cool. Since cold water cannot dissolve elements as readily as warm water, elements in the form of minerals begin to precipitate out of the solution. The minerals comprise the fractures or cracks forming veins.

Mark Distribution:

1 mark for indicating hydrothermal (or vein) mineral deposit.

1 mark for explaining that fractures or cracks in the overlying sedimentary layers are required.

1 mark for explaining how warm water can readily dissolve elements, whereas cold water cannot readily dissolve elements. Cold water leads to the precipitation of elements in the form of minerals that fills in the required fractures or cracks.

Common Errors and Commentary:

- Students did not mention that it was the pressure exerted by the intruding magma chamber or plume that caused the overlying sedimentary layers to fracture or crack.

- Students suggested that the magma intruded into the fractures or cracks causing the formation of mineral deposits.

- Students commented that the limestone layer (overlying the intrusion) hosting the fractures or cracks as well as the letter A was metamorphosed into marble as a result of the heat and pressure generated from the magma chamber or plume.

- Students commented that the sandstone layer (overlying the intrusion) was metamorphosed into quartzite as a result of the heat and pressure generated from the magma chamber or plume. This was a significant error since the sandstone layer did not host any fractures or cracks as well as the letter A. In this case, students simply did not think about the exact location of the letter A in the diagram.

- The majority of students indicated that igneous or metamorphic processes were occurring at letter A in the diagram. Only a minority of students correctly indicated that hydrothermal or vein was the type of mineral deposit that was formed at letter A.

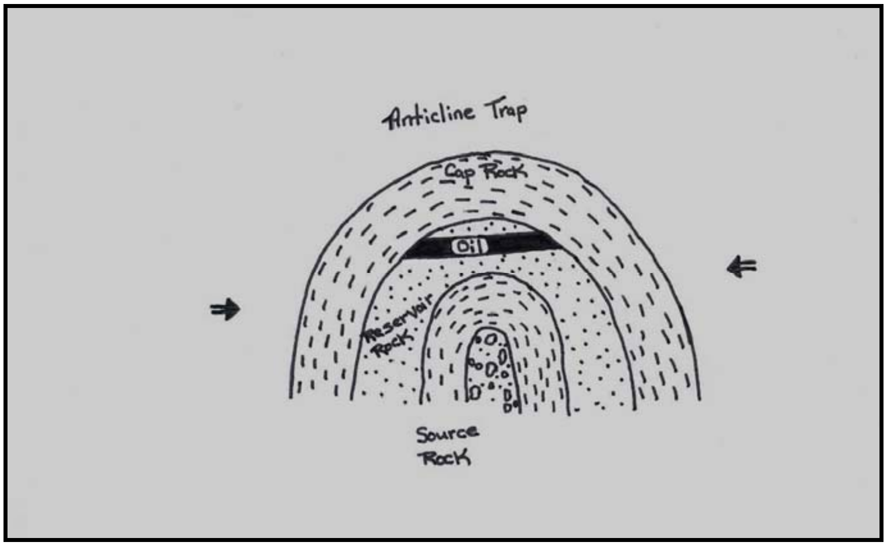
- For those students who indicated either hydrothermal or vein mineral deposit, most failed to explain how solution chemistry and related precipitation directly contributed to its formation. Students never explained how water temperature influenced the dissolving of minerals, the transportation of elements, and the precipitation of minerals.

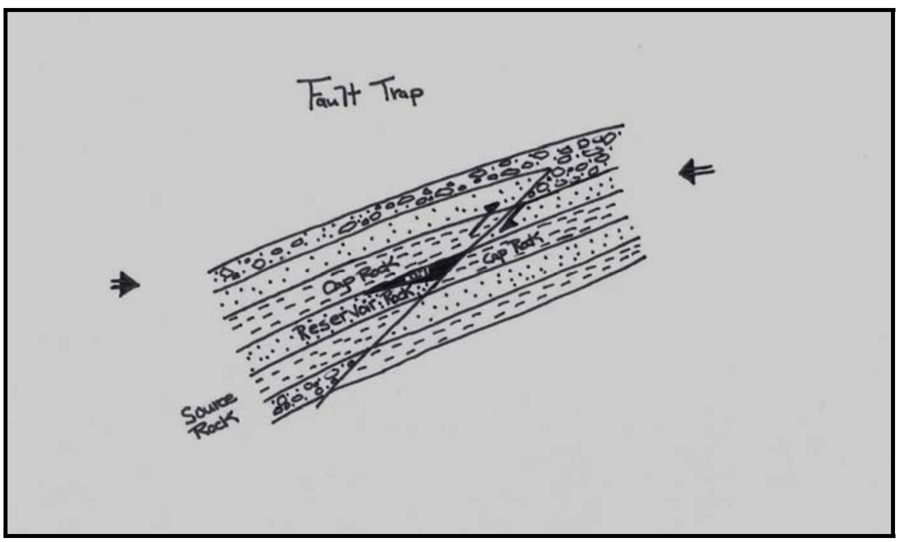
* The pertinent information for answering this question is embedded in column 2 and 3 of the curriculum guide. The question was marked on all papers but was not used in determining a student's mark if it was to the student's detriment.

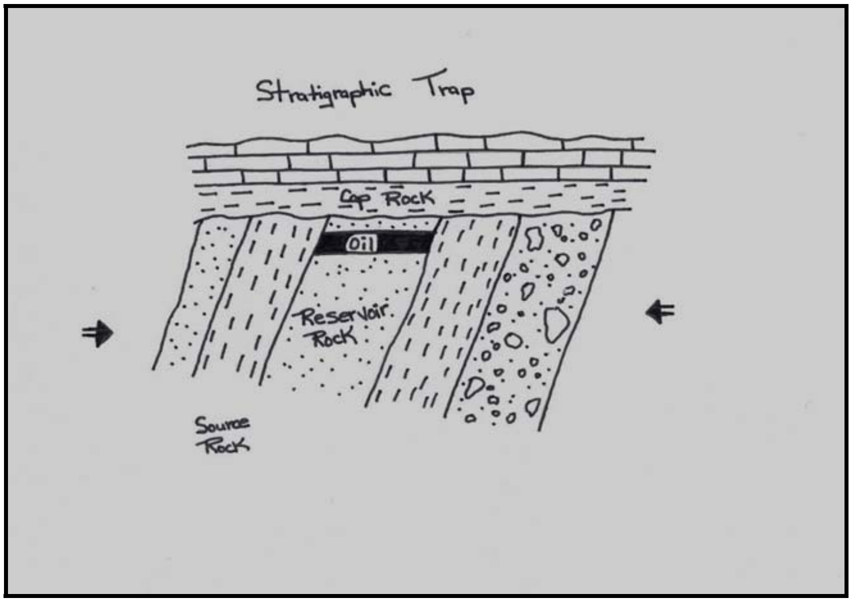
Value
2 %

63. (i) Draw and label a diagram to show an oil trap that resulted from the compression of sedimentary layers.

Answer:







Anticline traps, fault traps, and stratigraphic traps are commonly associated with compressional forces. Note that reverse faults (hanging walls moves up in relation to foot walls) are the fault type that forms from compressional forces. Note that only stratigraphic traps that involve angular unconformities are associated with compressional forces. The required components of either of the above oil traps include: source rock (e.g. shale); reservoir rock (e.g., sandstone, conglomerate, limestone); cap rock (e.g. shale); and the existence of oil in the trapped region of the reservoir rock. Note that the surface of the oil, as well as the gas and water if included in the diagram, in the trapped region should have a horizontal surface.

Mark Distribution:

0.5 mark for labeling source rock (e.g. shale) on the diagram.

0.5 mark for labeling reservoir rock (e.g., sandstone, conglomerate, limestone) on the diagram.

0.5 mark for labeling cap rock (e.g. shale) on the diagram.

0.5 mark for labeling the existence of oil (with a horizontal surface) in the trapped region of the reservoir rock.

Common Errors and Commentary:

- Several students constructed and labeled a salt dome trap; however, this type of oil trap does not result from the compression of sedimentary layers.

- The majority of students who constructed either an anticline, fault (i.e. reverse) or stratigraphic (i.e. involving an angular unconformity) trap failed to label all of the required components of the trap including: source rock; reservoir rock; cap rock; and the existence of oil in the trapped region of the reservoir rock. Source rock was the required component of the oil trap that was omitted most frequently by students.

- Many students correctly labeled the required components of an oil trap; however, the diagrams did not accurately depict the structures of either an anticline, fault (i.e. reverse), or stratigraphic (i.e. involving an angular unconformity) trap.

Value
3 %

63. (j) (i) Explain why both contact metamorphism and regional metamorphism are common around convergent plate boundaries.

(ii) What metamorphic texture is shown in the diagram?

Answer:

Convergent boundaries are when two crustal plates collide due to the converging motion of convection currents in the upper mantle (i.e. asthenosphere). There are three types of plate collisions which include: oceanic-oceanic; oceanic-continent; and continent-continent. All three types of plate collisions, due to the compressional forces that serve to generate pressure and heat, can result in regional metamorphism. The locations of the regional metamorphism could be in the sedimentary rocks that comprise continental shelves and the igneous rocks that comprise the continents. Contact metamorphism occurs when molten comes into contact with cold, pre-existing rocks. Molten results from the melting of crustal plates that have been subducted down into the mantle. Subduction of crustal plates occurs only at oceanic-oceanic and oceanic-continent collision locations. When the molten moves up through the cold, preexisting rocks of the crust, the result is metamorphism or baking of the rocks by the heat that is generated from the molten. The metamorphic texture that is evident in the diagram below is foliation or banding.

Mark Distribution:

1 mark for relating regional metamorphism to the process of mountain building, which is common along convergent plate boundaries. This is largely due to the existing compressional forces that result in intense pressure and heat.

1 mark for indicating that the rising of molten up through Earth's crust (in plumes or magma chambers) can metamorphose or bake the cold, pre-existing rocks that it comes into contact with along the way. The source of the molten is the melting of crustal oceanic plates that are subducted along convergent plate boundaries.

1 mark for indicating that the metamorphic texture which is evident in the rock sample in the diagram is foliation or banding.

Common Errors and Commentary:

- Many students commented on the fact that heat is the main criterion for causing contact metamorphism. Many students also commented on the fact that heat and pressure are the two main criteria for causing regional metamorphism. Students recognized that heat and pressure are both common around convergent plate boundaries; however, few of them explained why this was the case. For example, few students explained that a subducting oceanic plate results in the production of molten, which rises upwards baking and metamorphosing the overlying rocks that it contacts. As an additional example, few students explained that the compressional forces that result at convergent boundaries cause mountain building to occur, which serves to subject rocks that are deep beneath Earth's surface to intense pressure and heat causing regional metamorphism.

- Many students suggested that the heat and pressure that characterizes convergent plate boundaries serve to melt the surrounding rocks, thereby leading to both contact and regional metamorphism. These students failed to realize that melting is not a requirement in effectively metamorphosing rocks. To the contrary, hot chemical fluids such as water serve as the medium for the dissolving of minerals as well as the precipitation of minerals.

- Despite the diagram of the rock being clear, many students did not comment that the metamorphic texture is foliation (or banding). Many students commented that the texture was either porphyritic or non-foliated. Porphyritic is an igneous texture consisting of a number of large crystals (i.e. phenocrysts) surrounded by an abundance of small crystals (i.e. groundmass). Non-foliated is a metamorphic texture; however, it does not involve minerals in an orderly and aligned structure. Some students commented that the texture was granite or andesite; however, both are representative of igneous rocks and therefore, not even possibilities of texture. Many students commented that the texture was striations possibly since they mistook the foliation (or banding) as being scratches left on the rock's surface by a moving glacier. Many students commented that the texture was layers (or sedimentary layers) that had been deposited horizontally, but deformed at a later time.

Value
3 %

64. (a) All organisms require specific conditions in order to be fossilized in some way.

(i) In the Badlands of Alberta, one layer of Jurassic sediments has evidence that dinosaurs lived in the area. Besides bones, what other evidence could have been collected to support this finding?

(ii) Occasionally, jellyfish have been found in the fossil record. Identify one condition necessary for its fossilization.

Answer:

Trace fossils serve as evidence that dinosaurs once lived in the Badlands of Alberta. These fossils serve as indirect evidence since no actual remains of the organisms exist in the layer of Jurassic sediments. Examples of trace fossils include footprints, gastroliths, and coprolites. Dinosaurs could have stepped in sediment and the footprint rapidly buried by fine-grained sediment, thereby being fossilized. Dinosaurs ingested stones into their digestive tracks and they would have remained in a localized area after the dinosaurs had decayed forming what are called gastroliths. Dinosaur dung could be fossilized through the method of mold and cast forming coprolites.

Note: It is possible that dinosaurs' skin could be fossilized through the process called carbonization. Carbonization involves the leaching out of oils from organic compounds leaving matter as films of carbon. Similarly, dinosaurs' eggs could be fossilized if they were rapidly buried by fine-grained sediment. Since neither are examples of trace fossils, but is evidence besides bones indicating that dinosaurs once lived in the area, both are acceptable responses. **1 mark** each would be given for listing the above fossil types and explaining how both could have formed.

Since a jellyfish is soft-bodied and not hard-bodied, it would have to be buried rapidly (or quickly) in order for fossilization to occur.

Mark Distribution:

1 mark for indicating that trace fossils serve as indirect evidence that dinosaur once lived in the area. Indirect evidence since the actual remains of the dinosaurs (e.g. bones) is not fossilized.

1 mark for providing a trace fossil (e.g., footprint, gastrolith, coprolite) and explaining how it formed.

1 mark for indicating that rapid (or quick) burial is the one condition necessary for fossilization, particularly since a jellyfish is soft-bodied in contrast to being hard-bodied.

Common Errors and Commentary:

- Many students failed to not only mention trace fossils, but to explain what they represent and how they were formed. Many students mentioned examples of trace fossils such as tracks, trails, footprints, dung (i.e. coprolites), and stomach stones (i.e. gastrolithes); however, they did not explain what they represent and how they were formed.

- Some students commented that entire dinosaurs could have been fossilized as either a mold or cast; however, the constructed response item specifically asked for evidence that could have been collected besides bones.

- Despite some students commenting that petrifaction by replacement could serve as evidence that dinosaurs once lived in the Badlands of Alberta, they failed to indicate that dung is what could be fossilized by this method.

- Despite some students commenting that carbonization could serve as evidence that dinosaurs once lived in the Badlands of Alberta, they failed to indicate that skin, which is largely comprised of carbon atoms, is what could be fossilized by this method.

Value
3 %

64. (b) On the diagram, draw lines to indicate the three main geologic zones on the island of Newfoundland. Briefly describe the origin of each of the geologic zones.

Answer:

The three major geologic zones on the island of Newfoundland include: Western (or Humber); Central (or Dunnage and Gander); and Eastern (or Avalon). The Western Zone was a part of ancient Laurentia or North America (i.e. Humber Zone). The Eastern Zone was a part of ancient Gondwanaland or Africa (i.e. Avalon Zone). These two zones represent crustal plates that collided and as a result, represent a convergent boundary that featured compressional forces. These forces caused subduction of one oceanic plate underneath the other oceanic plate leading to melting in the upper mantle (i.e. asthenosphere) and the existence of several island arc volcanoes on the surface (i.e. Dunnage Zone). These pressures, combined with intense heat and hot chemical fluids, also lead to both regional and contact metamorphism (i.e. Gander Zone). The volcanoes, metamorphism, and remaining oceanic crust characterize the Central Zone of the province.

Mark Distribution:

1.5 marks for labeling the three geologic zones on the diagram (i.e. Western Zone, Central Zone, and Eastern Zone).

1.5 marks for correctly explaining the origins of the three geologic zones.

Common Errors and Commentary:

- Many students correctly identified the names and locations of the three main geologic zones on the island of Newfoundland; however, they failed to briefly describe the origin of each of the geologic zones.

- Many students briefly described the rock types associated with the three main geologic zones on the island of Newfoundland; however, the constructed response item indicates that a description of the origin of each of the geologic zones was required.

- Many students incorrectly labeled the Central Zone as being the Humber Zone.

- Many students correctly described the origin of the Western Zone and the Eastern Zone; however, many of them did not correctly and/or completely describe the origin of the Central Zone. Many students commented that the Central Zone was a result of the collision between the Western Zone and the Eastern Zone; however, they failed to comment that the oceanic crust beneath the Iapetus Ocean as well as the formation and existence of numerous island arc volcanoes and metamorphic rocks contribute to the nature of the Central Zone.

- Many students incorrectly described the origin of the Eastern Zone as being a part of Europe as opposed to being a part of Africa (or Gondwanaland).

Table 1
EARTH SYSTEMS 3209
PUBLIC EXAMINATION – JUNE 2009
PART I (MULTIPLE CHOICE) – ITEM ANALYSIS

Item #	Answer	Responses			
		A	B	C	D
		%	%	%	%
1	A	50.3	6.4	8.5	34.8
2	A	39.1	46.2	11.1	3.2
3	A or B	67.6	27.2	4.9	0.3
4	C	2.0	7.3	85.9	4.8
5	B	10.6	46.7	9.2	33.4
6	D	14.1	2.3	0.7	83.0
7	A	82.8	8.8	6.0	2.5
8	A	59.2	21.5	15.8	3.6
9	A	75.7	16.2	7.4	0.7
10	D	4.1	11.4	18.2	66.3
11	D	3.2	7.8	52.1	36.7
12	C	8.2	13.9	73.7	4.1
13	D	16.8	21.8	6.5	54.5
14	C	15.9	11.8	52.1	20.0
15	B	19.8	63.8	10.6	5.7
16	A or C	33.6	12.3	50.4	3.7
17	C	28.9	12.2	56.8	2.1
18	B	15.5	76.9	1.2	6.2
19	B	18.6	48.3	8.8	24.3
20	A	77.2	11.8	2.0	9.0
21	C	13.8	32.6	52.1	1.3
22	A	65.3	19.9	6.5	8.2
23	A	43.6	41.1	11.1	4.0

Item #	Answer	Responses			
		A	B	C	D
		%	%	%	%
24	A	60.1	22.3	8.8	8.6
25	B	9.6	45.9	25.3	19.0
26	B	16.8	60.2	7.4	15.3
27	B	4.5	89.4	1.6	4.5
28	B	15.9	41.6	12.2	30.2
29	B	10.3	74.9	11.8	2.9
30	B	3.2	70.0	23.9	2.9
31	C	3.3	0.7	90.6	5.4
32	D	11.7	12.9	39.8	35.7
33	C or D	19.1	9.3	36.7	34.8
34	C	8.4	10.2	72.6	8.6
35	C	14.7	1.9	70.7	12.6
36	C	28.0	28.0	43.0	1.1
37	D	6.0	10.2	25.2	58.6
38	A	40.7	24.9	24.1	10.1
39	C	5.7	8.6	58.1	27.6
40	C or D	13.7	17.0	25.3	43.9
41	C	32.6	33.0	28.9	5.3
42	C	2.3	17.6	77.2	2.9
43	D	12.2	45.4	8.5	33.8
44	A	53.7	19.9	18.7	7.7
45	A	56.2	20.3	12.3	10.9
46	C	2.3	8.4	76.0	13.4
47	-	-	-	-	-

Item	Answer	Responses			
		A	B	C	D
		%	%	%	%
48	C	1.2	1.2	95.9	1.6
49	D	28.3	24.1	17.4	30.1
50	D	11.4	8.4	18.6	61.7
51	B	2.0	92.3	5.2	0.5
52	A	84.6	2.4	5.6	7.3
53	C	4.9	2.5	72.6	20.0
54	A	38.2	16.6	23.6	21.1
55	B	18.3	47.6	27.2	6.8
56	C	3.9	1.9	83.6	10.7
57	C	0.4	19.2	78.9	1.5
58	A	68.3	18.2	6.0	7.4
59	B	13.8	65.1	19.4	1.6
60	B	5.7	92.7	1.5	0.1

NOTE: Percentages may not add to 100 % due to missing values.

Table 2
EARTH SYSTEMS 3209
PUBLIC EXAMINATION – JUNE 2009
PART II (CONSTRUCTED RESPONSE) – ITEM ANALYSIS

Item #	Number Of Students	Value	Average
61.(a)	754	2%	1.3
61.(b)	754	2%	0.7
62.(a)	754	2%	0.8
62.(b)	754	2%	1.0
63.(a)	754	2%	0.9
63.(b)	754	2%	0.8
63.(e)	754	2%	0.8
63.(f)	754	2%	0.9
63.(g)	754	4%	2.4
63.(i)	754	2%	0.5
63.(j)	754	3%	0.8
64.(a)	754	3%	1.0
64.(b)	754	3%	1.2