UNIVERSITY OF JOHANNESBURG

FACULTY	: Science
DEPARTMENT	: Geology
CAMPUS	: APK
MODULE	: GLG01A1/GLG1A10 MINERALS, ROCKS AND EARTH DYNAMICS
SEMESTER	: First
EXAM	: SSA 2 July 2019

DATE	: July 2019	**SESSION**	:
ASSESSOR(S)	: PROF AJB SMITH		
MODERATOR	: DR D ROSE		
DURATION	: 3 HOURS	**MARKS**	: 180

NUMBER OF PAGES: 3 PAGES

INSTRUCTIONS:

1. Answer ALL THE QUESTIONS.
2. Number your answers clearly

QUESTION 1 – MULTIPLE CHOICE

1.1 Aside from the Earth, the terrestrial planets are
A. Mars, Mercury, and Venus.
B. Mars, Venus, and Jupiter.
C. Jupiter, Saturn, Uranus, and Neptune.
D. Mars and Saturn.

(2)

1.2 The primary evidence that our Sun is a third-, fourth-, or fifth-generation star comes from the fact that our
A. Solar System contains too many heavy atoms to be first-generation.
B. Solar System is too large to be first-generation.
C. Sun is too hot to be a first-generation star.
D. Sun is too large to be a first-generation star.

(2)

1.3 The atmosphere is divided into several distinct layers. From the ground up they are, in order,
A. stratosphere, troposphere, mesosphere, and thermosphere.
B. troposphere, stratosphere, thermosphere, and mesosphere.
C. troposphere, stratosphere, mesosphere, and thermosphere.
D. stratosphere, troposphere, thermosphere, and mesosphere.

(2)

1.4 The densest layer of the Earth is the
A. crust. B. outer core.
C. mantle. D. inner core.

(2)

1.5 Alfred Wegener saw Pangaea as a jigsaw puzzle, where the puzzle pieces were
A. oceans. B. mid-ocean ridges.
C. continents. D. plate tectonics.

(2)

1.6 Volcanoes that are submerged beneath the surface of the sea are termed
A. abyssal plains. B. mid-ocean ridges.
C. fracture zones. D. seamounts.

(2)

1.7 An earthquake would be LEAST likely at a(n)
A. active margin. B. continent-continent convergent zone.
C. passive margin. D. subduction zone.

(2)

1.8 In a hot-spot volcanic island chain, such as the Hawaiian Islands, which of the following is true?
A. All volcanoes in the chain can be simultaneously active.
B. The ages and distance between volcanoes can be used to calculate plate velocities.
C. The presence of volcanism is related to a plate boundary.
D. The magma source moves to form a hot-spot track.

(2)

1.9 The atomic number of an element corresponds to the
A. number of electrons. B. number of neutrons.

C. number of protons. D. total weight of one atom.

(2)

1.10. Minerals are grouped into mineral classes primarily on the basis of

A. chemistry, specifically the cations within the chemical formula.
B. chemistry, specifically the anions within the chemical formula.
C. hardness; hard, soft, and medium are the three primary classes.
D. the number of cleavage directions present.

(2)

1.11 Which of the following processes is not responsible for the formation of magma within the Earth?

A. decompression (due to a drop in pressure)
B. addition of volatiles
C. transfer of heat from adjacent magma or very hot rocks
D. loss of volatiles to the atmosphere

(2)

1.12 If you find a tuff in the field, what type of geologic activity could you reasonably assume has occurred?

A. an igneous intrusion B. a volcanic eruption
C. sea-level rise D. tectonic uplift

(2)

1.13 When limestone becomes chemically altered so that half of the calcium atoms are replaced by magnesium, the resultant rock is termed

A. agate. B. jasper.
C. dolostone. D. travertine.

(2)

1.14 Which environment would most likely produce sedimentary deposits characterized by very well-sorted, very well-rounded grains that are nearly pure quartz?

A. river B. beach
C. glacier D. alluvial fan

(2)

1.15 A protolith

A. is always metamorphic rock.
B. is always igneous rock.
C. is always sedimentary rock.
D. may belong to any of the three primary rock types.

(2)

1.16 The mineral assemblage within metamorphic rock is

A. always identical to that found within its protolith.
B. dependent only on the mineral assemblage of its protolith.
C. dependent only on the temperature and pressure of formation.
D. dependent on both the mineral assemblage of its protolith and the temperature and pressure of formation.

(2)

1.17 The textural term for a basaltic lava flow that has a smooth, ropy appearance is _____.

A. pahoehoe B. pumice
C. a'a' D. ignimbrite

(2)

1.18 If a volcano was actively releasing a large amount of volcanic gas and then abruptly stopped, what might happen to the volcano in the near future?

A. It will become extinct because the magma supply has been rapidly withdrawn.

B. It will erupt effusively because the supply of volcanic gas has dissipated.
C. It will erupt explosively because the volcanic gases have no way to escape slowly.
D. It will erupt effusively because the gases have made the magma less viscous.

(2)

1.19 The point on the Earth's surface directly above the point where an earthquake occurs is termed the

A. hypocenter (focus). B. eye of the fault.
C. epicenter. D. vertex.

(2)

1.20 Which of the following hazards is most likely to occur days to weeks after an earthquake?

A. fire B. liquefaction
C. disease D. foreshocks

(2)

1.21 A body of rock affected by tensile stress will likely undergo _____.

A. shortening B. stretching
C. shear strain D. rotation

(2)

1.22 Mountain ranges formed along subduction zones are formed, in part, by _____ in the crust.

A. compression B. extension
C. stretching D. elongation

(2)

1.23 As understood by modern geologists, the principle of uniformitarianism implies that

A. the Earth has always had the same basic appearance that it has today.
B. igneous, metamorphic, and sedimentary rocks are uniformly mixed throughout the crust.
C. physical processes observed today (such as erosion and volcanic eruptions) have been active in the past at roughly the same rates.
D. physical processes observed today (such as erosion and volcanic eruption) occurred much more rapidly in the past, quickly sculpting the Earth's surface.

1.24 How much of a radioactive parent isotope will remain after three half-lives have passed?

A. one-third (1/3) B. one-eighth (1/8)
C. three-halves (3/2) D. one-sixth (1/6)

(2)

1.25 The Earth became internally differentiated, with a metallic core distinct from the rocky mantle, during the

A. Archean Eon. B. Proterozoic Eon.
C. Hadean Eon. D. Paleozoic Era.

(2)

1.26 The Cambrian Period is a time in the Earth's history when

A. the first abundant shelly organisms appeared in the fossil record.
B. the Earth's interior was so hot that a solid outer crust, if present, was likely being extensively remelted.
C. stable continental interiors, termed cratons, first formed.
D. the dinosaurs appeared and came to dominate large-scale terrestrial life.

(2)

1.27 Chemically, oil and gas are both _____.

A. pure forms of carbon B. hydrocarbons

C. carbohydrates D. carbonate minerals

(2)

1.28 Which of the following would make the best reservoir rock in a conventional hydrocarbon system?

A. high-porosity, high-permeability rock
B. low-porosity, low-permeability rock
C. high-porosity, low-permeability rock
D. low-porosity, high-permeability rock

(2)

1.29 The ability of a metal to be bent, molded, and stretched is termed _____.

A. tempering B. malleability
B. cold working D. dexterity

(2)

1.30 Mineral-rich veins within plutons, deposited by hot groundwater into fractures within rock, characterize _____ deposits.

A. hydrothermal B. residual mineral
C. placer D. sedimentary

(2)

(60)

QUESTION 2 – COSMOLOGY AND THE STRUCTURE OF THE EARTH

2.1.1 What is the Big Bang, and when did it occur according to current estimates?

(5)

The Big Bang proposes that all matter and energy in the Universe (1) started out as a single small point (1). It then exploded (1) and has been expanding ever since (1). It occurred ~13.8 billion years ago (1).

2.1.2 Except for the Earth, name the other three terrestrial planets in our solar system.

(3)

Mercury (1), Venus (1) and Mars (1).

2.2.1 What is the geothermal gradient?

(2)

The geothermal gradient is the rate of change/ increase in temperature (1) with depth (1).

2.2.2 Name which type of Earth material the following are:

a) Coal
Organic compound (1)
b) Quartz
Mineral (1)
c) Carbon dioxide
Volatile (1)

(3)

2.2.3 Compare oceanic and continental crust based on their composition and density.

(3)

Oceanic crust is mafic/basaltic (1) whereas continental crust is felsic/granitic (1). Oceanic crust is denser than continental crust (1).

(16)

QUESTION 3 – CONTINENTAL DRIFT AND PLATE TECTONICS

3.1.1 Was it possible for a dinosaur to walk from Paris to New York during the early Jurassic? Explain why or why not.

(3)

Yes it was (1). At that time North America and Europe were attached (1) in the supercontinent called Pangea (1).

3.1.2 How does the observed pattern of marine magnetic anomalies form, and how does its existence help prove plate tectonics?

(4)

The observed pattern of marine magnetic anomalies formed as seafloor spreading took place (1). As ocean basins grew along mid-ocean ridge axes, bands of seafloor with different polarities formed (1) and then moved away from the ridge axis (1). The pattern of stripes and the confirmation of the relationship between the widths of the stripes and the duration of chrons serve as proof of plate tectonics (1).

3.2.1 Compare the oceanic crust to the continental crust with respect to age. Why is this so?

(3)

Oceanic crust is younger than continental crust (1) because it is created at mid-ocean ridges and recycled back into the mantle at subduction zones (1). Continental crust does not get recycled back into the mantle via subduction (1), so it is generally much older.

3.2.2 Name and provide sketches of the three types of plate boundaries.

(6)

Convergent + sketch (2). Divergent + sketch (2). Transform + sketch (2).

(16)

QUESTION 4 – EARTH MATERIALS: MINERALOGY AND ROCK TYPES

4.1.1 What are the ways a mineral can crystallize in nature?

(5)

Minerals can form during solidification of a melt (1), precipitation from a liquid solution (1), diffusion in solids (1), biomineralization (1), and as precipitates from volcanic gases around volcanic vents (1).

4.1.2 How can you determine the hardness of a mineral? On which scale is hardness usually measured?

(3)

This can be used using a scratch test (1), where a harder material or mineral will scratch a softer mineral (1). Hardness is usually measured on the Mohs hardness scale (1).

4.2.1 Why do magmas rise to the surface of the Earth?

(2)

Due to the buoyancy of the melt (1) as well as the pressure caused by the weight of overlying rocks (1).

4.2.2 What is fractional crystallization? Briefly explain how it works and why different types of magmas result.

(4)

Fractional crystallization is a process of sequential crystal formation (1) in a magma that progressively modifies the composition of the magma (1). As crystals form and sink during the freezing process, they are isolated from the magma and leave the composition of the magma changed (1). This change occurs because elements such as iron and magnesium are removed from the melt within crystalline solids. Depending on when the magma ultimately completely freezes, a spectrum of igneous compositions (from mafic to felsic) may result (1).

4.2.3 How are dykes and sills the same and how are they different?

(3)

Dykes and sills are both intrusive igneous features (1), but a dyke crosscuts the surrounding bedding (1) whereas a sill is parallel to the surrounding bedding (1).

4.3.1 Describe the difference between lithification and diagenesis.

(3)

Lithification is the transformation of loose sediment into intact sedimentary rock via compaction and cementation (2). Diagenesis is the process (chemical, biological, or physical) by which any sedimentary rock is produced/post-lithification processes affecting a sedimentary rock (1).

4.3.2 What is an alluvial fan? How is it different from a marine delta?

(4)

An alluvial fan is a wedge-shaped accumulation of sediment (usually sand and gravel) (1) deposited in an arid environment (1), typically at the edge of a mountain front where fast-moving streams empty onto a plain (1). A marine delta is an accumulation of sediment where a river enters the sea (1).

4.4.1 Use a sketch to name the three polymorphs of Al_2SiO_5 and place them at their respective metamorphic conditions.

(4)

Sketch (1) showing kyanite (lower T and P) (1), andalusite (high P lower T) (1) and sillimanite (higher T) (1).

4.4.2 What is a metamorphic aureole? What is the relationship between grade of metamorphism and proximity to the intrusion? What types of conditions are responsible for the formation of an aureole?

(4)

A metamorphic aureole is a zone of altered (metamorphosed) rock that forms adjacent to an igneous intrusion (1). Each layer of the aureole has progressively lower-grade metamorphism the farther it is from the intrusion (1). The metamorphism created by the intrusion is called thermal metamorphism or contact metamorphism (1). This type of metamorphism takes place in the absence of change in pressure with an increase in temperature (1).

(32)

QUESTION 5 – THE DYNAMIC EARTH: VOLCANOES, EARTHQUAKES AND MOUNTAIN BUILDING

5.1.1 Name and briefly define the three main products produced by volcanic eruptions.

(6)

Volcanic gases (1): expelled vapor and aerosols (1). Pyroclastic debris (1): fragments blown out of a volcano (1). Lava flows (1): molten rock that moves over the ground (1).

5.1.2 How does a caldera form? Provide a simple sketch of a caldera.

(3)

A caldera forms when a magma chamber empties below a volcano (1) and the volcano collapses into the empty space (1). Sketch (1).

5.2.1 In which four geological settings can earthquakes occur?

(4)

Convergent (1), divergent (1) and transform plate boundaries (1) as well as in intraplate settings (1).

5.2.2 Explain how sediment liquefaction occurs in an earthquake and how it can cause damage.

(4)

Liquefaction occurs when ground shaking causes a build-up of water pressure between sand grains (1) that then pushes them apart (1), causing quicksand-like behaviour (1). This can topple buildings and cause soil to lose strength (1).

5.3.1 What types of geologic structures would you expect to find in an area that had undergone compression?

(3)

Name three examples (3). Answers will vary; however, students should mention folding, reverse and thrust faulting, and perhaps tectonic foliation. They should not mention normal faulting.

5.3.2 Compare and contrast domes and basins. If both are composed solely of sedimentary beds that have been eroded such that the ground surface is level, how would you identify each?

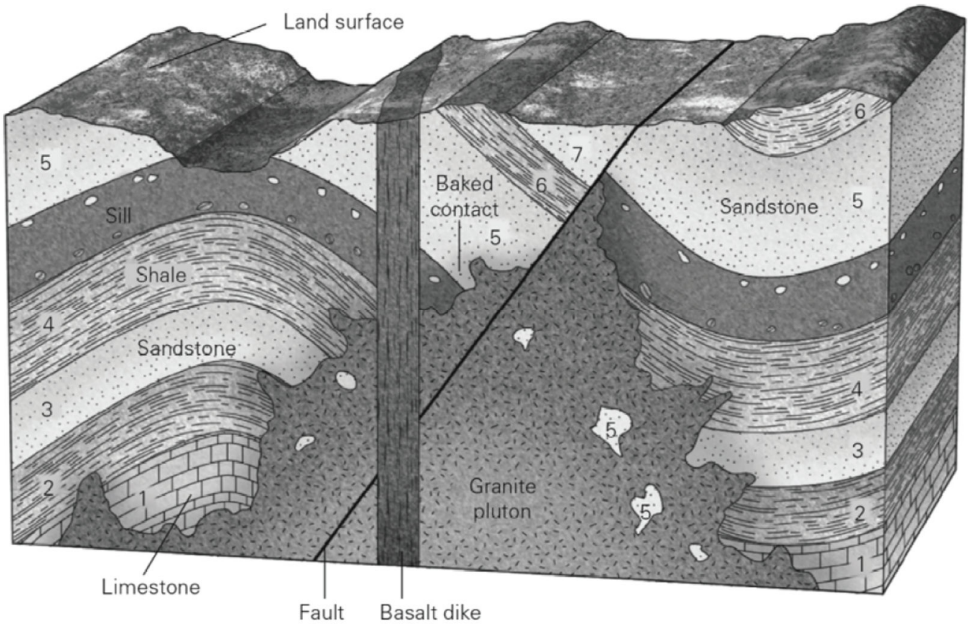
(4)

Domes and basins are types of folds that result from plastic deformation. A fold with the shape of an overturned bowl is a dome (1), whereas a fold shaped like an upright bowl is a basin (1). The oldest beds are exposed in the center of a dome (1). In a basin, the youngest beds crop out in the center (1).

(24)

QUESTION 6 – HISTORY OF THE EARTH

6.1.1 Place the geological units in the diagram below from oldest to youngest.



(6)

From oldest to youngest: 1, 2, 3, 4, 5, 6, 7, sill, folding, granite, faulting, basalt dike, land surface erosion (1/2 mark for each in the correct order).

6.1.2 Why have no rocks older than 4.12 Ga been found in the Earth's crust?

(2)

Rocks older than 4.12 Ga were likely re-melted during the heavy bombardment (1) or were recycled by passing through the rock cycle (1).

6.2.1 What caused the buildup of oxygen in the atmosphere at roughly 2.5 Ga?

(3)

Photosynthetic organisms (1) produced more oxygen than could be absorbed or dissolved by other environments (1). This caused a rapid buildup in the concentration of oxygen in the atmosphere (1).

6.2.2 What is meant by the term "snowball Earth?" What period of time in the Earth's history does this refer to and what were conditions like at this time? Support your answer with evidence.

(5)

Near the end of the Proterozoic Eon (1), radical climate shifts took place, resulting in a global ice age (1). Glacial sediments have been found in late Proterozoic stratigraphic sequences (1), suggesting multiple episodes of glacial growth even in

regions that were located at the equator at the time of deposition (1). It is hypothesized that at times glaciers covered all land areas and the oceans froze over—snowball Earth (1).

(16)

QUESTION 7 – EARTH RESOURCES

7.1.1 What is meant by the term fossil fuel? Where did the energy in a fossil fuel originate? What three energy resources are fossil fuels?

(5)

Fossil fuels—oil, natural gas, and coal (3)—come from organisms that lived long ago (1), so they store solar energy (1) that reached the Earth long ago. The term fossil fuel is used to emphasize the fact that they were derived from ancient organisms, the remains of which have been preserved in rocks over geologic time.

7.1.2 What are the main challenges related to nuclear energy?

(3)

Expensive and hard to maintain (1), potentially dangerous if an accident should happen (1), storage of nuclear waste (1).

7.2.1 What is the difference between an ore mineral and other minerals, and between an ore and other kinds of rocks?

(5)

In ore minerals the weight ratio of metal to non-metal (1) is high (1), whereas other minerals have a low weight ratio of metal to non-metal (1). Ores have economic concentrations (1) of commodities/metals (1) in them whereas other rocks do not.

7.2.2 Distinguish between cement and concrete.

(3)

Cement is a complex group of minerals that precipitate from a water solution (1). Concrete is a mixture (1) of cement and aggregate (sand, gravel, or crushed rock) (1).

(16)

(Grand total: 180)