Senior High School

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Earth Science for STEM

Quarter 2 – Module 3:
Endogenic Processes:
Plutonism and Volcanism

ALTERNATIVE DELIVERY MODE
ADM

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Quarter 2 – Module 3: Endogenic Processes: Plutonism and Volcanism
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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

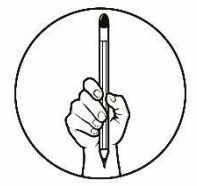
What I Need to Know

This module was designed and written to help you understand concepts on Endogenic Processes such as plutonism and volcanism. The scope of this module allows it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of the learners.

This module contains significant activities in which you will be able to describe the endogenic processes specifically Plutonism and Volcanism which involves the magma formation.

After accomplishing this module, you are expected to:

1. identify the composition of magma;
2. discuss how magma is formed; and
3. explain what happens after magma is formed.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Magma varies widely in composition. Which is the most abundant element composition in magma?
    a. Aluminum
    b. Oxygen
    c. Silicon
    d. Sodium

2. What is the tendency of the magma with high silica content?
    a. It tends to be hotter.
    b. It tends to be less viscous.
    c. It tends to be more viscous.
    d. It tends to be less explosive.

3. What is the effect of the magma's high viscosity on volcanic eruption?
    a. It becomes less explosive.
    b. It becomes more explosive.
    c. It has less magma emission.
    d. It has more magma emission.

4. Magma plays an important role in geologic processes. Which of the following best describes magma?
    a. a molten rock
    b. a molten metal

c. a mixture of liquids and gases
d. a molten rock came out to the Earth's surface

5. Which geologic process takes place inside cracks and infiltrates the upper mantle allowing liquids and gases to reach the surface of the earth?
   a. Plutonism
   b. Hydration
   c. Tectonic
   d. Volcanism

6. Why does partial melting of rocks occur on the earth's mantle?
   a. Because rocks are made of metals.
   b. Because rocks are pure materials.
   c. Because rocks are made up of silicates.
   d. Because rocks' composition has different melting points.

7. What rock is produced when the process of crystallization takes place inside the crust?
   a. Plutonites and Volcanites
   b. Plutonites
   c. Volcanites
   d. None of the above

8. Which of the following factors affect the melting of rocks?
   a. temperature and pressure
   b. pressure and minerals components of a rock
   c. temperature and minerals components of a rock
   d. temperature, pressure and mineral components of a rock

9. Which geologic process occurs on the earth's surface correlated with flow and transportation of igneous material?
   a. Metamorphism
   b. Plutonism
   c. Volcanism
   d. Seismic activities

10. Geologist found out that rocks melted under various pressures. Which of the following best describes how pressure affects the melting of rocks?
    I. The higher the pressure, the lower the melting point.
    II. The lower the pressure, the higher the melting point.
    III. The higher the pressure, the higher the melting point.

    a. I and II
    b. II only
    c. III only
    d. II and III

11. Which statement best describes plutonism?
    a. A geological phenomena that occurs on the surface of the earth
    b. A motion that takes place inside the cracks that infiltrate the upper mantle
    c. A process where magma infiltrates the Earth's crust but fails to make it to the surface
    d. A process correlated with the flow and transportation of igneous material towards the surface

12. Which igneous rock formation is produced when the process of crystallization takes place on the Earth's surface?
    a. Plutonites and Volcanites
    b. Plutonites
    c. Volcanites
    d. None of the above

13. What condition is ideal for metallogenesis?
    a. magma differentiation occurs
    b. magma reaches the Earth's surface
    c. magma infiltrates the Earth's crust but fails to make it to the Earth's surface.
    d. magma infiltrates the Earth's crust, fails to make it to the Earth's surface and magma differentiation occurs.

14. What happens during flux melting?
    a. Rock's melting point is reduced when mixed with some water or carbon dioxide.
    b. Rock's melting point is increased when mixed with some water or carbon dioxide.
    c. Rock's melting point is reduced when mixed with some oxygen or carbon dioxide.
    d. Rock's melting point is increased when mixed with some oxygen or carbon dioxide.

15. What temperature and pressure conditions allow magma to form?
    I. low pressure and low temperature
    II. high pressure and low temperature
    III. low pressure and high temperature

    a. I only
    b. I and II
    c. II and III
    d. III only

Lesson 3 Endogenic Processes: Plutonism and Volcanism

We know that the Earth transmits seismic waves which makes the planet solid for thousands of kilometers down to the core-mantle boundary. The evidence of volcanic eruptions, however, tells us that there must be liquid regions where magma originates.

What's In

In the previous module, you learned that primordial heat, spontaneous radioactive decay, gravitational pressure and dense core materials are the reasons why Earth's interior is hot. These Earth's internal heat fueled different endogenic activities that enable the planet to sustain life.

Meanwhile, in this new lesson, you will learn information about magmatism as one of the endogenic processes. Specifically, you will understand concepts on composition of magma, how it is formed and what happens after it's formed.

Notes to the Teacher

This Self-Learning Module encourages learners to answer independently. However, you must orient the learners to answer ALL ACTIVITIES included in this module.

What's New

Magma is found beneath the surface of the Earth, and evidence of magmatism has also been discovered on other terrestrial planets and some natural satellites. The poem below will give you an idea on the composition and properties of magma.

Read the poem silently, then identify the properties of magma. Write your answer on a separate sheet of paper.

What is Magma?
by: Razel M. Ferrer

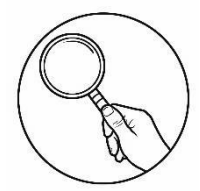
Magma is a combination of molten rocks
And gases of the Earth's mantle and cores
Temperature ranges from 600-1300 degree Celsius
And comprises of mineral mixtures.

Magma varies widely in composition
But in general, only 8 elements are on
Namely oxygen, silicon, aluminum and iron
Potassium, sodium, magnesium and calcium.

The most abundant element in magma is oxygen
Which comprises a little less than half of the total
And over one quarter, followed by silicon
The other one quarter is for other elements in all.

Vast amount of heat causes magma's temperature to rise
In that case, melting point may reach for some minerals
But pressure also plays an important role as well
For materials to melt partial this way.

Magma's properties and composition
Are truly impressive and awesome
But what happens after it was formed?
That's a question, I want to be informed.



What is It

An **endogenic process** is a geological process that was formed, originated, and located below the surface of the earth. It involves geologic activities such as tectonic movements, metamorphism, seismic activities and magmatism.

How is magma formed?

Magma is formed under certain circumstances in special location deep in the crust or in the upper mantle. **Magma** forms from partial melting of mantle rocks.

Rocks undergo **partial melting** because the minerals that compose them melt at different temperature. Partial melting takes place because rocks are not pure materials. As temperature rises, some minerals melt and others remain solid. If the same conditions are maintained at any given temperature, the same mixture of solid and melted rock is maintained. To visualize the partial melt, think of how chocolate chip cookies would look if you heated it to the point at which chocolate chips melted while the main part of the cookie stayed solid. The chips represent the partial melt or magma. (https://opentextbc.ca/geology/chapter/3-2-magma-and-magma-formation/)

To understand melting, pressure is also considered. Pressure increases with depth as a result of the increased weight of overlying rock. Geologists found out that as they melted rocks under various pressures, higher pressure led to higher melting points.

According to Bayo-ang, et.al (2016), the two main mechanisms through which rocks melt are **decompression melting** and **flux melting**.

Decompression melting takes place within Earth when a body of rock is held at approximately the same temperature but the pressure is reduced. This happens because the rock is being moved toward the surface, either at a **mantle plume** (a.k.a., hot spot), or in the upwelling part of a mantle convection cell. If a rock that is hot enough which is close to its melting point is moved toward the surface, the pressure is reduced, and the rock can pass to the liquid side of its melting curve. At this point, partial melting starts to take place.

Flux melting happens if a rock is close to its melting point and some water or carbon dioxide is added to the rock, the melting temperature is reduced and partial melting starts.

As the magma moves toward the surface, and especially when it moves from the mantle into the lower crust, it interacts with the surrounding rock. This typically leads to partial melting of the surrounding rock because most such magmas are hotter than the melting temperature of a crustal rock.

At very high temperatures (over 1300°C), most magmas are entirely liquid because there is too much energy for the atoms to bond together. As the temperature drops, usually because the magma is slowly moving upward, things start to change. Silicon and oxygen combine to form silica tetrahedra, and then, as cooling continues, the tetrahedra start to link together to make chains (**polymerize**). These silica chains have the important effect of making the magma more viscous (less runny), and magma viscosity has significant implications for more explosive volcanic eruptions.

As the magma continues to cool, crystals start to form. (https://opentextbc.ca/geology/chapter/3-2-magma-and-magma-formation/)

What happens after magma is formed?

Cuarto (2016) described that magma escaped in two forms: intrusion and extrusion.

An **intrusion** is magma that moves up into a volcano without erupting. Like a balloon, this causes the volcano to grow on the inside. What is meant by the intrusion of magma is the inclusion of the rock layers forming the earth's crust (magma does not get out).

Plutonism

- Plutonism refers to all sorts of igneous geological activities taking place below the Earth's surface.
- In cases where magma infiltrates the Earth's crust but fails to make it to the surface, the process of magma differentiation gives birth to ideal conditions for metallogenesis and that is a kind of Plutonism.
- This is the exact process that gives birth to magma, when the presence of various oxides, fluorine, sulfur, and chlorine compounds that are necessary for the creation of magma is guaranteed.
- The solidification and crystallization of magma takes place mainly inside the Earth's interior.

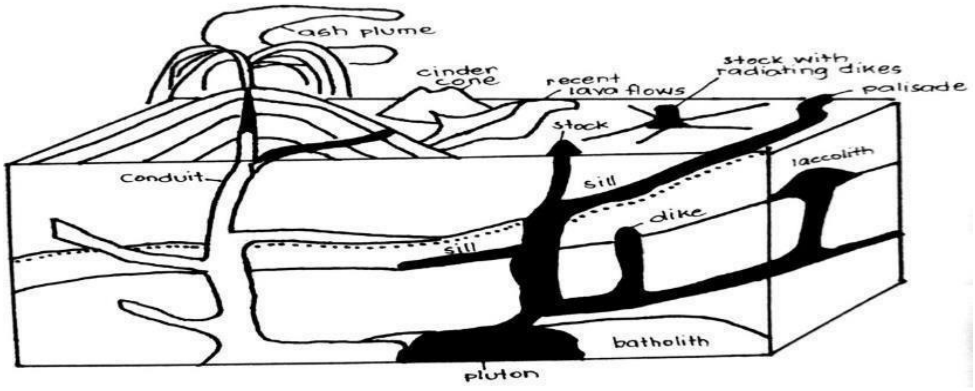


Figure 1. Plutons and Volcanic landforms

When the process of crystallization takes place inside the crust, the magmatic rocks produced are called **plutonites**, which is another major category of igneous rock formation. Plutonites are igneous rock formations that are created when the process of crystallization and solidification of magma takes places below the Earth's surface and particularly in the crust.

An **extrusion** is an eruption of magmatic materials that causes land formation on the surface of the Earth. Magma extrusion causes the formation of volcanoes when the gas pressure is strong enough and there are cracks in the earth's crust. Magma that came out to the surface of the earth is called the eruption. Magma that came to the surface of the earth is called lava.(http://page-edu.blogspot.com/2014/02/volcanism-intrusion-and-extrusion-of.html)

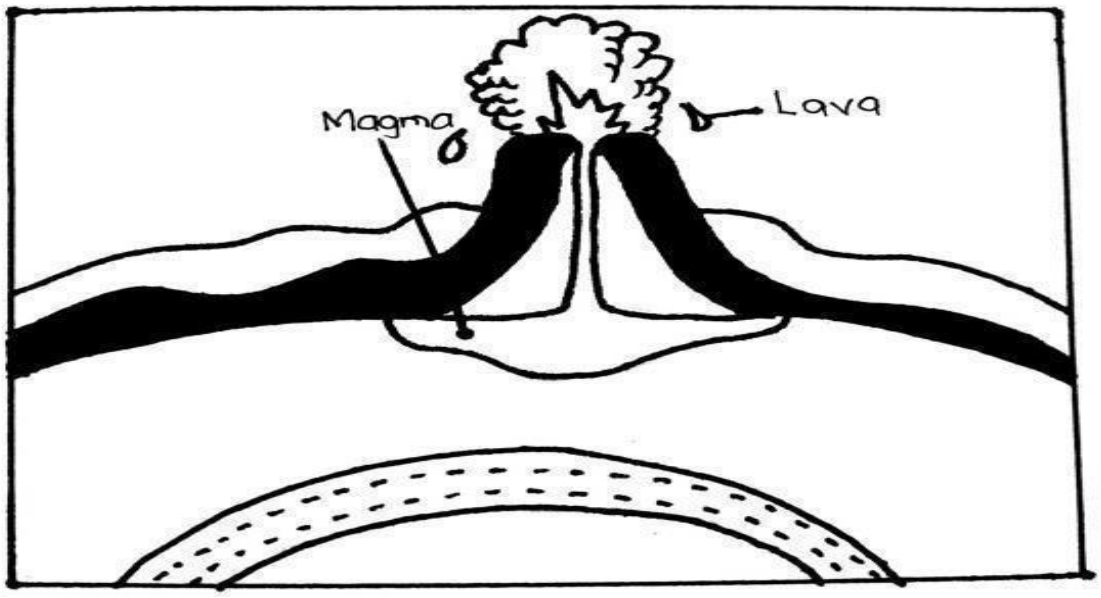


Figure 2. The Movement of Magma

Magma can move up because of a high pressure exerted by magma and gases. In the lithosphere, magma occupies a bag which is called magma chamber. The depth of the magma chamber causes the differences in the strength of volcanic eruptions. In general, the deeper the magma chamber, the stronger the explosion.

Volcanism

- Volcanism is used to describe all geological phenomena that occurs on the natural terrestrial surface, such as the creation of volcanoes and hot springs. (Grotzinger et.al ,2008)

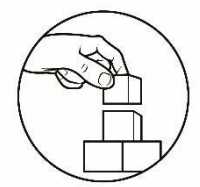
- It refers to all sorts of geological activities correlated with the flow and transportation of igneous material from the planet's interior towards the natural terrestrial surface.

- This motion takes place inside the cracks that are known among geologists as natural pipes that infiltrate the upper mantle. In many cases, the mantle allows massive quantities of liquids and gases to reach the upper layers of the planet and in various cases, even the natural terrestrial surface.

Volcanoes are created and formed when the energy generated by inductive currents flowing from the Earth's core towards the surface hits the upper layers in the form of pressure and smashes the overlaying rock formations. The presence of

dilated water vapor plays an important role in the creation of craters by assisting the flow of magma towards the surface. This also explains why massive amounts of water vapor concentration in magmatic gases with an average value of 80% are emitted into the atmosphere during volcanic eruptions.

Molten material in the form of lava that undergoes the process of crystallization on the natural terrestrial surface gives birth to rock formations known as volcanites. These are one of the major categories of igneous rock formations. Volcanites are composed of gray, dull pink colored track basaltic lava with large phenocrysts and pyroclastic.

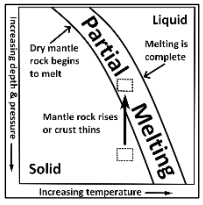


What's More

After reading the details on the geologic processes within the Earth, let's see if you understand it by answering the following activities.

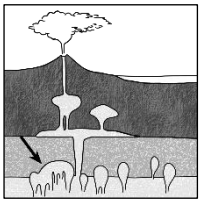
Identify the terms related to the given geologic processes using the given illustrations. Arrange the jumbled letters that follow each statement. Write your answer in a separate sheet of paper.

1. Melting that takes place within Earth when a body of rock is held at approximately the same temperature, but the pressure is reduced.



N S M P D E C O R E S I O

2. This happens when some minerals melt, and others remain solid.

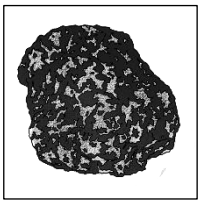


I T R P A A L E M L I N T G

3. An eruption of magma that causes the volcano to grow on the outside.

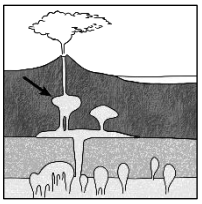
S I O T R U N E X

4. Magmatic rocks that crystallized inside the crust.



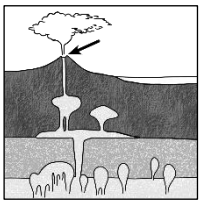
L O U T E S P N I T

5. It refers to all sorts of igneous geological activities that take place below the Earth's surface.



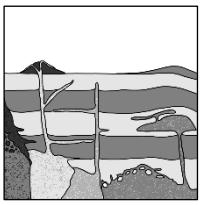
N P T O I L U S M

6. It is the geological phenomena that occurs on the surface of the earth.



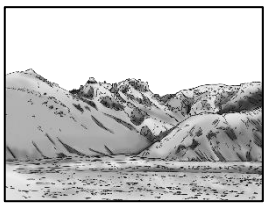
M A C V O L N I S

7. A magma that moves up into a volcano without erupting



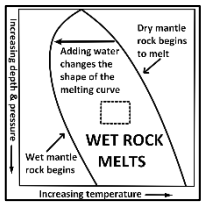
I O N R U I N T S

8. Magmatic rocks that crystallized in the natural terrestrial surface.



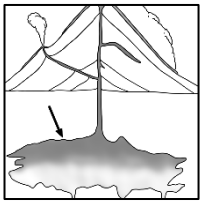
E S V A N I T O L C

9. Melting that takes place when temperature is reduced



X F L U

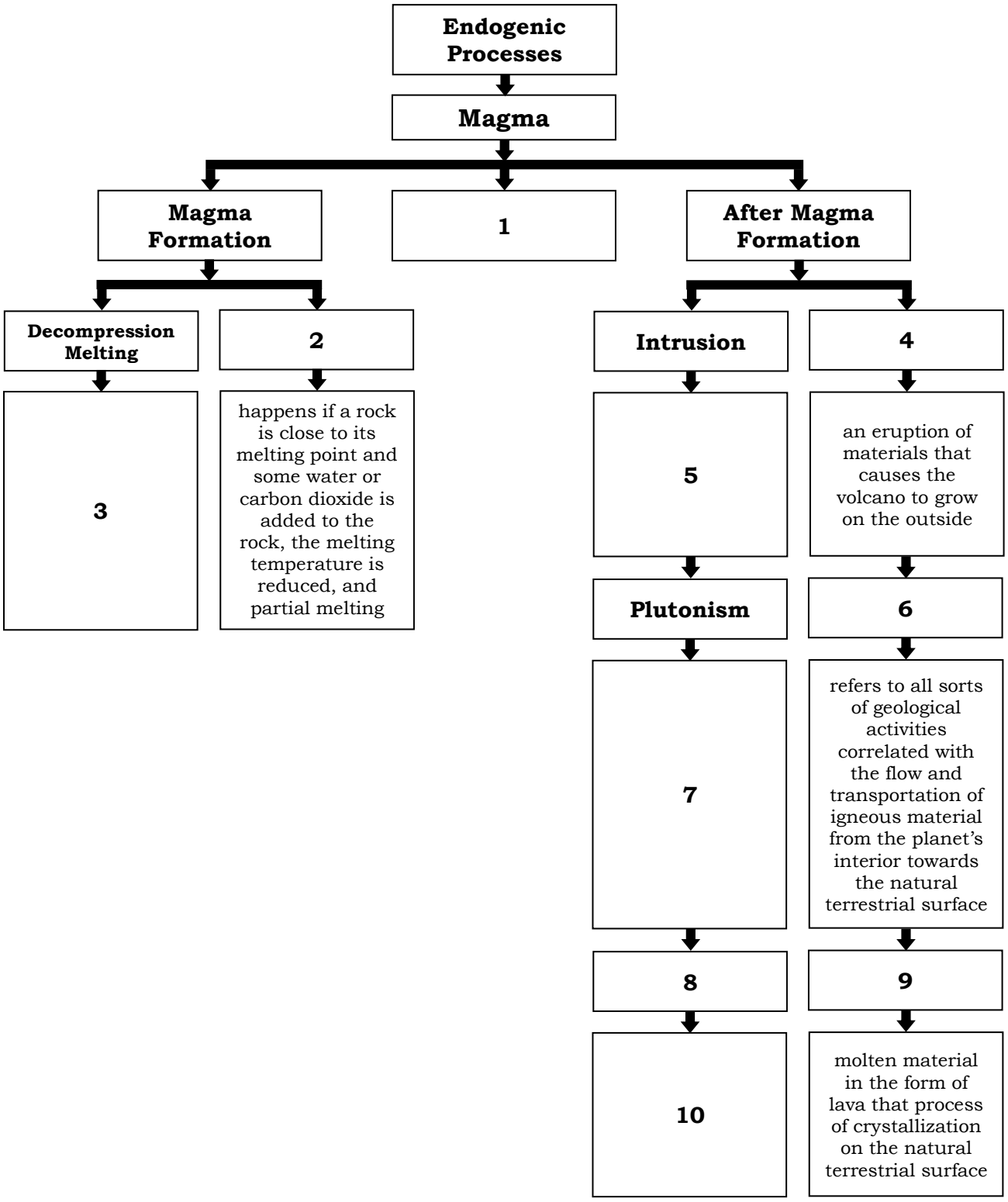
10. It forms from the partial melting of mantle rocks.



A A M G M

What I Have Learned

Complete the concept map below. Write your answers in a separate sheet of paper.



What I Can Do

Read the article below and answer the guide questions on a separate sheet of paper.

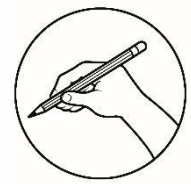
Figure 3. Taal Volcano during eruption last January 12, 2020. Photo taken by Mr. Apolonio Enriquez a resident of Bilibinwang, Agoncillo, Batangas during their evacuation.

Last January 12, 2020, Taal Volcano was awakened from its long sleep and spewed tons of gases and ashes to the surrounding municipalities of Batangas and the neighboring provinces of Cavite and Laguna. The phreatic type of explosion was observed on the first day, lasted for many days and a slight magmatic explosion was also observed on he second day. Lockdown was imposed on the municipalities surrounding the Taal Volcano which includes Agoncillo, San Nicolas, Taal and Lemery for almost one month. It ended when PHIVOLCS declared alert level 2 and observed that the level of seismicity, gas emission and other parameters decreased. However, PHIVOLCS declared that the volcano island was a permanent danger zone which meant no residents were allowed to go back in their houses in that area. On the other hand, residents were insisting to go back on their houses in Taal Volcano island because they believed that the eruption was over since small amount of gases were emitted by the volcano and earthquakes were already not felt.

Guide Questions

1. If you are a resident of the island, will you go back to your houses? Why or why not?
2. Using the concepts that you have learned in this module, what can you infer from the cause of sudden volcanic eruption of Taal? Why do you think it stopped?

CRITERIA	5	4	3	2	1
Explanation	All information provided is accurate. The answer demonstrates a deep understanding of the content.	The answer is missing 1 detail. All information provided is accurate. The answer demonstrates understanding of the content.	The answer is missing 2 details. Almost all information provided is accurate. The answer demonstrates basic understanding of the content.	The answer to the question is lacking any detail. Some information provided is accurate. The answer demonstrates a lack of understanding of the content.	Question is not answered. A small amount to none of the information provided is accurate. The answer demonstrates a lack of understanding of the content.
Textual evidence	At least 2 details from the text were included to support the claim being made. The details included were accurate, clear, and properly supported the claim.	At least 2 details from the text were included to support the claim being made. However the details included were somewhat unclear and/or included minor errors in fact.	At least 1 detail from the text was included to support the claim being made. However the detail included was somewhat unclear and/or included minor errors in fact.	At least 1 detail from the text was included to support the claim being made. However the detail included was very unclear and/or included major errors in fact.	Paragraph(s) have no textual evidence and/or All textual evidence provided is inaccurate.



Assessment

Directions: Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. How does decompression melting occurs?
    a. It occurs when the temperature is constant but the pressure increases.
    b. It occurs when the temperature is constant but the pressure decreases.
    c. It occurs when the temperature decreases directly proportional to pressure.
    d. It occurs when the temperature increases inversely proportional to pressure.

2. How is magma formed?
    a. Magma is formed through movement of rocks and minerals.
    b. Magma is formed under the earth's mantle through solar radiation.
    c. Magma is formed through heating and cooling of materials on the earth's surface.
    d. Magma is formed under certain circumstances in special location deep in the crust or in the upper mantle of the Earth.

3. What happens after magma is formed?
    I. Magma escapes by intrusion.
    II. Magma escapes by extrusion.
    III. Magma escapes to the bodies of water.
    IV. Magma escapes through a magma chamber.

    a. I, II and III
    b. I, II and IV
    c. I, III and IV
    d. II, III and IV

4. Which of the following statements is correct?
    a. High viscous magma means higher temperature, more silica content, and less violent eruption.
    b. High viscous magma means higher temperature, less silica content, and more violent eruption.
    c. High viscous magma means lower temperature, less silica content, and less violent eruption.
    d. High viscous magma means lower temperature, more silica content, and more violent eruption.

5. Which set of elements are all present in magma?
    a. Silicon, Lithium, Iron, Manganese
    b. Oxygen, Silicon, Iron, Aluminum
    c. Nitrogen, Potassium, Calcium, Aluminum
    d. Iron, Calcium, Silicon, Lithium

6. What is the tendency of a magma with high silica content?
    a. It tends to be hotter.
    b. It tends to be less viscous.
    c. It tends to be more viscous.
    d. It tends to be less explosive.

7. Which of the following statements describe volcanism?
    I. A geological phenomena that occurs on the surface of the earth
    II. The motion takes place inside cracks that infiltrate the upper mantle
    III. The process where magma infiltrates the crust but fails to make it to the surface
    IV. A process correlated with the flow and transportation of igneous material towards the surface

    a. I, II and III
    b. I, II and IV
    c. I, III and IV
    d. II, III and IV

8. To which activity can you compare partial melting of mantle rocks?
    a. Butter and chocolate bars are heated together until they both melted.
    b. Chocolate bars with almond and pistachio nuts are heated until all the chocolates melted while the nuts remained solid.
    c. Vanilla ice cream was left to melt on the table.
    d. Ice cubes disappeared in a pitcher of orange juice.

9. Which of the following statements do not describe plutonism?
    I. A geological phenomena that occurs on the surface of the earth
    II. A motion that takes place inside cracks that infiltrate the upper mantle
    III. A process where magma infiltrates the crust but fails to make it to the surface
    IV. A process correlated with the flow and transportation of igneous material towards the surface

    a. I, II and III
    b. I, II and IV
    c. I, III and IV
    d. II, III and IV

10. At what temperature will magma turn entirely to liquid?
    a. More than 2000 degrees Celsius
    b. Between 1000 and 1200 degrees Celsius
    c. Between 800 to 1000 degrees Celsius
    d. More than 1300 degrees Celsius

11. Which condition will initiate the combination of silicon and oxygen to form silica tetrahedra that link together to make chains or to polymerize?
    a. Magma rapidly moving upward towards the Earth's surface while its temperature remains constant.
    b. Magma rapidly moving upward towards the Earth's surface thus increasing its temperature.
    c. Magma slowly moving upward towards the Earth's surface thus increasing its temperature.
    d. Magma slowly moving upward towards the Earth's surface thus decreasing its temperature.

12. What happened during flux melting?
    a. Rock's melting point is reduced when mixed with some oxygen or carbon dioxide.
    b. Rock's melting point is increased when mixed with some water or carbon dioxide.
    c. Rock's melting point is reduced when mixed with some water or carbon dioxide.
    d. Rock's melting point is increased when mixed with some oxygen or carbon dioxide.

13. What temperature and pressure conditions allow magma to form?
    I. low pressure and low temperature
    II. high pressure and low temperature
    III. low pressure and high temperature

    a. I only
    b. I and II
    c. III only
    d. II and III

14. Why does partial melting of rocks on mantle occur?
    a. Because rocks composition has different melting points.
    b. Because rocks are made of metals.
    c. Because rocks are made up of silicates.
    d. Because rocks are pure materials.

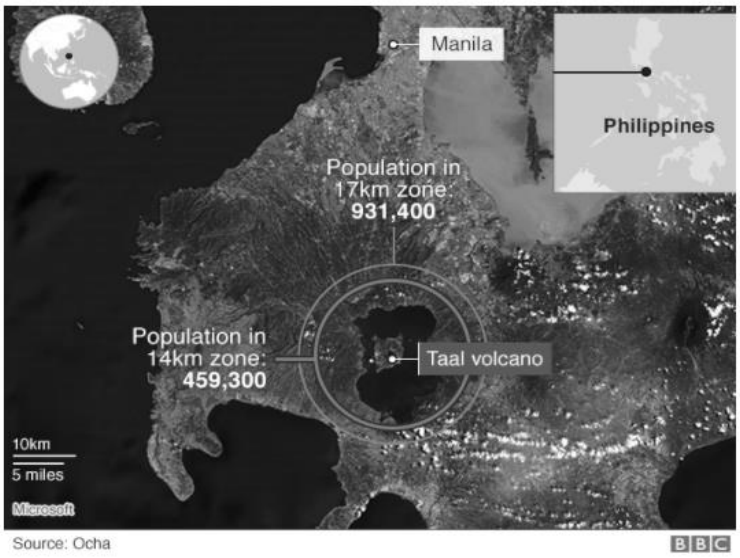
15. Which of the following factors affect the melting of rocks?
    a. temperature and pressure
    b. pressure and mineral components of a rock
    c. temperature and mineral components of a rock
    d. temperature, pressure and minerals components of a rock

Additional Activities

Analyze the given diagram, then answer the question on a separate sheet of paper.\

As of July 2021, Taal Volcano has erupted 35 times in 448 years. (https://www.rappler.com/newsbreak/iq/timeline-taal-volcano-eruptions)

How will you anticipate the impact of an eruption on people and the environment ten years from now using this diagram?



Source: https://ichef.bbci.co.uk/news/640/cpsprodpb/0B7B/production/_110493920_philippines_taal_volcano_640-nc.png

Category	4	3	2	1
Content	It shows an understanding of the topic's concepts and principles and uses appropriate terminology and notations, There is no misconceptions or errors evident.	It has some mistakes in terminology or shows a few misunderstandings of concepts. Few misconceptions are evident.	It has many mistakes in terminology and shows a lack of understanding of many concepts. Some misconceptions are evident.	It does not show understanding of the topic's concepts and principles. It has many misconception
Organization of ideas	It is well organized in a logical format.	It is organized and easy to follow.	It is somewhat organized and incoherent.	It is confusing and misleading.
Number of pertinent words	At least 25 pertinent words were used	At least 20 pertinent words were used	At least 15 pertinent words were used	At least 10 pertinent words were used
Accuracy of relationship of words	All the concepts are significant and accurately related to each other.	Some concepts are significant and accurately related to each other.	Few concepts are significant and accurately related to each other.	The concepts given are not related to each other.
Textual evidence	At least 2 details from the text were included to support the claim being made. The details included were accurate, clear, and properly supported the claim.	At least 2 details from the text were included to support the claim being made. However the details included were somewhat unclear and/or included minor errors in fact.	At least 1 detail from the text was included to support the claim being made. However the detail included was somewhat unclear and/or included minor errors in fact.	At least 1 detail from the text was included to support the claim being made. However the detail included was very unclear and/or included major errors in fact.
			Total Score:	

Answer Key

What's More

1. DECOMPRESSION
2. PARTIAL MELTING
3. EXTRUSIVE
4. DISCORDANT
5. PLUTONISM
6. VOLCANISM
7. INTRUSIVE
8. CONFORMABLE
9. FLUX
10. MAGMA

What I Have Learned

1. Volcanism
2. Plutonism
3. Intrusion
4. Extrusion
5. Decompression
6. Flux
7. Conformable
8. Discordant

Assessment

1. b
2. d
3. b
4. d
5. b
6. c
7. b
8. b
9. b
10. d
11. d
12. c
13. a
14. d
15. d

What I Know

1. b
2. c
3. b
4. d
5. d
6. d
7. b
8. d
9. c
10. c
11. c
12. c
13. d
14. a
15. d

What's New

Properties:

1. molten rocks
2. temperature from 600-1300 Celsius

Composition:

1. combination of liquids and gases
2. comprised of mineral mixtures
3. consists of oxygen, aluminum, silicon, iron, potassium, magnesium, calcium

References

Books

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