

GLY4310

56 points

Name _____

March 26, 2020

4- took exam - Numbers to the left of the question number in red are the number of incorrect responses. Instructor comments are in blue.

Florida Atlantic University
PETROLOGY -- MIDTERM TWO KEY

This examination is a TAKE-HOME exam. You may use your textbook, lecture notes, and PowerPoint presentations. It is due at 12:30 p.m. on March 31, 2020. Please complete it using WORD. Rename the file using your last name followed by the regular file name (i.e. lastname_4310M2_S20.docx). Return it as an e-mail attachment from your FAU e-mail account. Remember you are bound by the provisions of the **FAU Honor Code**.

True-False - Print the letter T or F in the blank to indicate if each of the following statements is true or false. Illegible answers are wrong. (1 point each)

4 T 1. Laccoliths intrusions are usually mafic, with lower viscosity magma than lopoliths.

2 F 2.

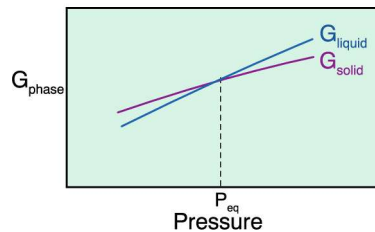
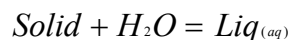


Figure 1

At pressures above P_{eq} in Figure 1, the stable substance will be liquid.

0 F 3. If $P_f = P_{\text{total}}$, the magma is dry.

0 T 4. For the reaction,



removing water will drive the reaction to the left.

- 0 T 5. Lherzolite is a type of peridotite with olivine > orthopyroxene + clinopyroxene.
- 1 F 6. When using isotopic ratios, like $^{143}\text{Nd}/^{144}\text{Nd}$ or $^{87}\text{Sr}/^{86}\text{Sr}$, mass fractionation during melting or crystallization is a problem.
- 0 T 7. Most fast-spreading ridges are found in the Pacific Ocean.
- 0 T 8. On a plot of La/Sm vs. Mg#, E-MORB's characteristically have a higher La/Sm ratio than N-MORB's, whatever the Mg#.
- 0 F 9. Most volcanoes, especially those in the southern hemisphere, plot along a line between DM and HIMU on a plot of $^{208}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$.

Multiple-Choice - Choose the best response to each statement or question. Print the letter corresponding to your choice in the blank. (1 point each)

- 0 A 1. Which of the following is not a depositional volcanic feature?
A. Maar
B. Scoria cone
C. Tuff cone
D. Tuff ring
- 0 C 2. Which type of volcanic vent is largest?
A. Cinder cone
B. Dome
C. Shield
D. Strato or composite
- 0 C 3. A careful examination of an exposed pluton yielded the following observations:
1. Common miarolitic cavities
2. Sharp discordant contacts were present
3. Borders were chilled, and some contact metamorphism of the country rock was observed, but no regional metamorphism was observed
4. Nearby volcanic eruptions were sampled, and radiometric age dating revealed both the plutonic rock and the volcanic rock had the same age
- At what depth was this pluton emplaced?
A. Catazone
B. Mesozone
C. Epizone
D. Either A or B

- 0 D 4. Observable field evidence for an active hydrothermal system associated with a shallow intrusion includes which of the following?
A. Fumaroles
B. Geysers
C. Hot springs
D. Any or all of the above
- 0 A 5. A Canadian geologist who was one of the most important pioneers in the field of experimental petrology was:
A. Norman Levi Bowen
B. Jean Léonard Marie Poiseuille
C. Alfred Edward Ringwood
D. Peter John Wyllie
- 1 D 6. In a binary eutectic system where one end member is mafic and the other felsic, what effect will an increase of pressure have on the eutectic point?
A. It will shift toward the mafic mineral, and decrease in temperature
B. It will shift toward the mafic mineral, and increase in temperature
C. It will shift toward the felsic mineral, and decrease in temperature
D. It will shift toward the felsic mineral, and increase in temperature
- 0 B 7. The alkaline magma series may be found in all of the following environments EXCEPT:
A. Convergent plate margin
B. Divergent plate margin
C. Convergent intraplate
D. Divergent intraplate
- 0 B 8. Which lherzolite phase forms at the shallowest depths?
A. Garnet
B. Plagioclase
C. Spinel
- 0 C 9. This oceanic layer is split into two sublayers. The upper, has isotropic gabbro on top of transitional (somewhat foliated) gabbro. The lower sublayer is layered gabbros with cumulate textures. The layering ranges from horizontal to steeply dipping. Which ocean layer is this?
A. Layer 1
B. Layer 2
C. Layer 3
D. Layer 4

- 0 D 10. Which oceanic layer, made of ultramafic rocks, contains the petrological MOHO?
A. Layer 1
B. Layer 2
C. Layer 3
D. Layer 4
- 1 B 11. Which of the following basalt types has the most distinct K/Ba ration?
A. E-MORB
B. N-MORB
C. OIA
D. OIT
- 0 A 12. Pb is quite scarce in the mantle. Mixing of mantle material with crustal material will greatly change the observed lead-lead isotopic ratios. Which isotopic ratio is the most sensitive indicator of crustal contamination in the mantle?
A. $^{206}\text{Pb}/^{204}\text{Pb}$
B. $^{207}\text{Pb}/^{204}\text{Pb}$
C. $^{208}\text{Pb}/^{204}\text{Pb}$
- 0 D 13. Which phase of the Hawaiian eruption sequence produces most of the volcanoes seen in the Hawaiian Islands?
A. Post-erosional
B. Post-shield
C. Pre-shield
D. Shield-building
- 0 D 14. Alkaline magmas are produced in all stages of the Hawaiian eruption sequence EXCEPT:
A. Post-erosional
B. Post-shield
C. Pre-shield
D. Shield-building

Fill-Ins - Write in the word or words which best completes each statement or answers each question. (1 point per blank)

- 0, 0 1-2 For volcanic ash, what are individual particles called? 1) PYROCLASTS, What is the collective term for all deposited material? 2) TEPHRA
- 0 3. Deposits from pyroclastic flows are called IGNIMBRITES, which comes from the Greek for “fire cloud material”.
- 0 4. Deep intrusive bodies are called PLUTONS.
- 0 5. A group of rocks that share some chemical, and sometimes mineralogical, characteristics are called a MAGMA SERIES (2 words). They share patterns on chemical variation diagrams which suggests a genetic relationship
- 0 6. A PARENTAL MAGMA is the most primitive magma type within a given magma series, it may or may not be primary
- 3 7. When several minerals are precipitating simultaneously from a magma, the system may be described as MULTIPLY SATURATED.
- 0 8. The geomorphic feature is 1-3 kilometers above the ocean floor, and averages 2000 kilometers in width. What is it? MID OCEAN RIDGE

Discussion questions - Write a complete, concise answer to each of the following questions. Diagrams (labeled) may be used to supplement your written answers, where appropriate, and must be shown where requested. Points as shown

- 2.0 1. Discuss the factors that influence the viscosity of magma. How and why does each factor influence the viscosity? (4 points)
- A. Temperature
 - B. Magma composition
 - C. Volatile content - how does pressure affect this?

As temperature increases, viscosity drops. The higher the temperature, the more energy molecules have, making them move faster and vibrate more, which increases fluidity.

The higher the silica content, the higher the viscosity. Bonding in liquids mimics the bonding seen in the minerals that are eventually produced from the melt. Felsic magmas have a great deal of Si and Al, which tend to form chains like Si-O-Si-O or Si-O-Al-O. The bonds in which oxygen is between two Si ions or an Si and an Al ion are called bridging bonds. Bonds to cations like magnesium or iron are weaker, and are non-bridging. Bridging results in polymerization. The longer the polymerized chains, and the more chains that form, the higher the viscosity.

The presence of water and alkali elements (volatiles) reduces viscosity. This occurs because these substances substantially reduce the chain length in polymers.

Volatile content plays another role for shallow intrusives, or extrusives. As the magma rises, confining pressure is reduced. Volatiles begin to escape from solution, forming a separate phase. When gas pressure > confining pressure, the gas may produce an explosive eruption, with a rapid loss of volatiles.

- 1 2. State the Clapeyron equation. For the dry case, on going from solid to liquid, is the slope of dP/dT positive or negative. Explain why? (4points)

The Clapeyron is

$$\frac{dP}{dT} = \frac{\Delta S}{\Delta V}$$

On going from solid to liquid, entropy increases, so ΔS is positive. For the dry case, on going from solid to liquid, ΔV is also positive, so $\Delta S/\Delta V$ must be positive.

- 1.5 3. Why is water solubility is greater in felsic minerals like feldspar and quartz, than in mafic olivine? (2 points)

Felsic minerals have bridging oxygens, which link silica tetrahedra, while mafic minerals do not. Water molecules are capable of inserting themselves at the bridging oxygen so water is much more soluble in felsic minerals.

4.5 4. In systems with water and carbon dioxide, the observed solubilities of CO₂ for three minerals were:

Albite	5-6%
Enstatite	18%
Diopside	35%

Explain the solubility observations. What effect does water have on CO₂ solubility? (4 points)

It was suggested that the carbon dioxide dissolves by forming carbonate complexes in silicate melts, particularly when calcium is available to form CaCO₃. The carbon dioxide steals one oxygen, and converts another to a bridging oxygen. Since many oxygens in albite are already bridging, CO₂ is least soluble in albite. Diopside has Ca whereas enstatite does not, so CO₂ is more soluble in diopside.

Carbon dioxide thus tends to increase the polymerization of melts, again opposite to the effect of water. It should raise the viscosity of melts it is dissolved in. Since carbon dioxide is soluble in *less* polymerized melts, it becomes obvious why water increases carbon dioxide solubility. The water reduced polymerization, enhancing CO₂ solubility

2.0 5. Alpine peridotites were quite controversial up until the 1980's, when a reasonable explanation for them was found. What was that explanation? (1 point)

Alpine peridotites are ophiolites, pieces of the ocean floor which were thrust onto the continent, and then pushed upward into the Alps by a plate tectonic collision.

1.5 6. How can the increasing-decreasing sawtooth pattern produced by the Oddo-Harkins effect be removed from REE and Spider diagrams? (1 point)

The Oddo-Harkins effect can be eliminated by normalizing the concentrations relative to a standard. CI chondrites are often used for this purpose. The value for each element is divided by the value for that element in the CI chondrite.

0 7. Describe a Spider diagram. What does it plot? (1 point)

A spider diagram is a plot of rock/chondrite values for a wide range of trace elements.

0 8. When MORB data is plotted on a REE element and a Spider diagram, what pattern is seen? Can either partial melting or fractional crystallization produce this pattern? How might the pattern be explained? (3 points)

MORB shows a pattern of Heavy Rare Earth Element (HREE) enrichment, as well as enrichment in the heavier trace elements. Neither partial melting nor fractional crystallization can produce this effect. It has been suggested that the mantle is already Light Rare Earth Element (LREE) depleted.

0 9. The Sm/Nd ratio decreases in partial melts, or in late liquids undergoing fractional crystallization. Why? (1 point)

Both elements are LREE, and are incompatible. Neodymium has a lower atomic number than samarium, and is therefore slightly larger (lanthanide contraction). It is slightly preferentially concentrated into the liquid phase, relative to samarium.

0.5 10. Hot spot plumes forming below 660 kilometers may remain as solid diapirs rising toward the surface because the geotherm remains below the solid. What might cause them to melt? (1 point)

Decompressive melting can occur at shallower depths, forming a magma.

0.5

11. In a Fenner variation diagram, Mg is plotted on the abscissa decreasing from left to right. Why is it plotted this way? (1 point)

Lower Mg concentrations represent lower temperatures, so these diagrams show how the concentrations of various elements change as magma is cooling.

3.5

12. What is a Pearce element ratio diagram, and what is it used for? Describe how the diagram is constructed. (3 points)

A Pearce element ratio diagram is a bivariate diagram. It is designed to test for the fractional crystallization of a particular mineral. The denominator of both ratios is the same, generally a single element, which is not contained in the fractionating minerals. The numerators are linear combinations of elements reflecting the composition of the proposed fractionating mineral. Straight line plots in Pearce diagrams indicate a mineral may be fractionating, but do not prove it, so the Pearce element ratio diagram is a method proposed to indicate extracted phases.

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13. The “Infinite Onion” model of a spreading center axial magma chamber could explain sheeted dike complexes, and feed the pillow flows. Crystallization along the walls, top, and bottom of the chamber could create gabbros. Periodic injections of fresh magma, together with divergent plate movement, would continually expand the chamber, preventing the crystallization from completely filling the chamber. Why was this model rejected? (1 point)

Shallow magma chambers, full of liquid, should be readily detectable by seismic wave studies. But seismic studies have failed to locate magma chambers of any significant size beneath the axial ridges.

2.5

14. Diagrams of $^{143}\text{Nd}/^{144}\text{Nd}$ vs. $^{87}\text{Sr}/^{86}\text{Sr}$ show enrichments of $^{87}\text{Sr}/^{86}\text{Sr}$ beyond the values of the Bulk Earth. What method has been suggested to explain this? (1 point)

The reservoirs EMI and EMII, with enriched and highly enriched values of $^{87}\text{Sr}/^{86}\text{Sr}$ have been proposed.

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15. PREMA (Prevalent Mantle) is another proposed reservoir. It is in the middle of the mantle array, and can be made by mixing of other reservoirs. What was it proposed? (1 point)

The composition corresponds to several oceanic islands, including Easter Island, Hawaii, the Galapagos Islands, and Iceland, with large geographic diversity.

4.0

16. What does DUPAL stand for? What is distinctive about the DUPAL volcanoes? (2 points)

The DUPAL volcanoes were first identified by Bernard Dupré and Claude Allègre, French geologists. They do not plot on the Northern Hemisphere Reference Line (NHRL) in a plot of $^{208}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$, but appear to be enriched with either EMI or EMII. They are located in the Southern Hemisphere, near 30°S latitude.

By my signature, and under penalties of the **FAU Honor Code**, I certify that the work shown above is my own, and was not obtained from any other source, other than those listed in the instructions.

Signature

