Benha university
Faculty of science
Geology Dept.
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Fourth level
Special geology
Geochemistry (433 G)
Time: Two Hours

نموذج اجابة

Examination of Geochemistry (433 G) for the fourth level students (Geology), Jan., 2017

Answer three the questions only from the following.

1. Check whether the following statements are correct or not and correct the false if any? (12 Marks)

1- A primary magma: Is the first melt produced by partial melting within the **crust**, and which has not yet undergone any differentiation. **(False).**

A primary magma: Is the "first melt" produced by partial melting within the **mantle**, and which has not yet undergone any differentiation.

2- All primary magmas must have **> 10% Na2O** by weight. **(False)**

All primary magmas must have **> 10% MgO** by weight.

3- Tholeiitic rocks are Fe-rich, alkali **rich**, **peralkaline** and are common in oceanic ridges, intraplate-volcanoes ± convergent margins. **(False)**

Tholeiitic rocks are Fe-rich, alkali **poor**, **metaluminous** and are common in oceanic ridges, intraplate-volcanoes ± convergent margins.

4- Eu, when in its 2+ state, substitutes for Ca2+ in plagioclase feldspar more readily than the other rare earths. **(True)**.

5- A calc-alkaline magma is oxidized enough to precipitate significant amounts of the iron oxide magnetite, causing the iron content of the magma to **increase** as it cools than with a tholeiitic magma. **(False)**

A calc-alkaline magma is oxidized enough to precipitate significant amounts of the iron oxide magnetite, causing the iron content of the magma to **remain more steady** as it cools than with a tholeiitic magma.

6- Tholeiitic magmas are reduced; calc-alkaline magmas are oxidized. **(True)**.

7- MORB exhibits a light rare earth **enriched** pattern; upper continental crust is light rare earth **depleted** with a **positive** ‘Eu anomaly’. **(False).**

MORB exhibits a light rare earth **depleted** pattern; upper continental crust is light rare earth-**enriched** with a **negative** ‘Eu anomaly’.

8- When the parent magmas of basalts crystallize, they preferentially crystallize the more **iron-rich and magnesium-rich** forms of the silicate minerals olivine and pyroxene. **(False).**

When the parent magmas of basalts crystallize, they preferentially crystallize the **more magnesium-rich and iron-poor** forms of the silicate minerals olivine and pyroxene.

9- Nickel, with very similar chemical behavior to iron and magnesium, substitutes readily for them and hence is very **incompatible** in the mantle. **(False).**

Nickel, with very similar chemical behavior to iron and magnesium, substitutes readily for them and hence is very **compatible** in the mantle.

10- **Tholeiitic** basalts have a higher content of the alkalis, Na2O and K2O, than other basalt types. They also characterized by the development of modal nepheline in their groundmass. **(False).**

Alkali basalts have a higher content of the alkalis, Na2O and K2O, than other basalt types. They are also characterized by the development of modal nepheline in their groundmass.

11- With the calc-alkaline series, however, the precipitation of magnetite causes the iron-magnesium ratio to remain relatively constant, so the magma moves in a straight line towards **the magnesium corner on the AFM diagram**. **(False).**

With the calc-alkaline series, however, the precipitation of magnetite causes the iron-magnesium ratio to remain relatively constant, so the magma moves in a straight line **towards the alkali corner on the AFM diagram.**

12- Higher SiO2 content magmas have higher viscosity than lower SiO2 content magmas. **(True)**.

2. According to your geochemical knowledge complete the following statements. (12 Marks)

1. Certain minerals are practically confined to **deep-seated intrusive rocks**, such as **microcline, muscovite**.
2. There are some curious instances of rocks having the same chemical composition, but consisting of entirely different minerals such as **hornblendite** and **camptonites**. (Name two rocks and differentiate between them).
3. In spider diagrams elements are arranged in order of increasing compatibility (i.e., the more incompatible at the left).
4. Higher SiO_2 content magmas have higher viscosity than lower SiO_2 content magmas
5. Higher temperature magmas have **lower** viscosity than lower temperature magmas.
6. Water dramatically **reduces** viscosity, particularly of polymerized melts.
7. Gas gives magmas their **explosive** character, because volume of gas **expands** as pressure is **reduced**. The composition of the gases in magma are: H2O (water vapor), some CO2 (carbon dioxide) and Minor amounts of Sulfur, Chlorine, and Fluorine gases
8. Rhyolitic magmas usually have higher gas contents than basaltic magmas
9. During melting of wet rocks the temperature of beginning of melting first **decreases** with **increasing** pressure or depth, then at high pressure or depth the melting temperatures again begin to **rise**.
10. **A parental magma** is a magma capable of producing **all** rocks belonging to an igneous rock series by **differentiation.**
11. MORB, the acronym for typical mid-ocean-ridge basalt, is a type of tholeiitic basalt particularly low in incompatible elements.
12. OIAs tend to be **depleted** in Ni and Cr relative to MORBs.

3. a) Discuss the general characteristics of A-, S-, M- and I-type granites? (12 Marks)

	SiO_2	K_2O/Na_2O	Ca, Sr	A/(C+N+K)*	Fe^{3+}/Fe^{2+}	Cr, Ni	$\delta^{18}O$	$^{87}Sr/^{86}Sr$	Misc	Petrogenesis
M	46-70%	low	high	low	low	low	< 9‰	< 0.705	Low Rb, Th, U Low LIL and HFS	Subduction zone or ocean-intraplate Mantle-derived
I	53-76%	low	high in mafic rocks	low: metal-uminous to peraluminous	moderate	low	< 9‰	< 0.705	high LIL/HFS med. Rb, Th, U hornblende magnetite	Subduction zone Infracrustal Mafic to intermed. igneous source

S	65-74%	high	low	high peraluminous	low	high	> 9‰	> 0.707	variable LIL/HFS high Rb, Th, U biotite, cordierite Als, Grt, Ilmenite	Subduction zone Supracrustal sedimentary source
A	high than 77%	Na_2O high	low	var peralkaline	var	low	var	var	low LIL/HFS high Fe/Mg high Ga/Al High REE, Zr High F, Cl	Anorogenic Stable craton Rift zone

4. (A) Write short notes for the following: (16 Marks)

a) Goldschmidt's Classification

Goldschmidt recognized four broad categories: atmophile, lithophile, chalcophile, and siderophile.
Atmophile elements are generally extremely volatile (i.e., they form gases or liquids at the surface of the Earth) and are concentrated in the atmosphere and hydrosphere.
Lithophile, siderophile and chalcophile refer to the tendency of the element to partition into a silicate, metal, or sulfide liquid respectively.
Lithophile elements are those showing an affinity for silicate phases and are concentrated in the silicate portion (crust and mantle) of the earth.
Siderophile elements have an affinity for a metallic liquid phase. They are depleted in the silicate portion of the earth and presumably concentrated in the core.
Chalcophile elements have an affinity for a sulfide liquid phase

b) Nephelinite
Nephelinite: Is a volcanic rock with normative ol + lots of ne, and modal Ti-augite, Ol, feldspathoids ± phlogopite ± perovskite ± melilite in addition to matrix alkali feldspar.

c) Goldschmidt`s rules for the qualitative prediction of trace element affinities.
Goldschmidt (1937) also advanced some simple rules for the qualitative prediction of trace element affinities, based solely on the ionic radius and valence:
1. Two ions with the ***same radius and valence*** should enter into solid solution in amounts proportional to their concentration. In other words, they should behave about the same. Using this rule, one can predict the general affinity for some trace elements by analogy with a major element with similar charge and radius. This type of substitution is often called ***camouflage***. For example, Rb might be expected to behave as does K, and concentrate in K-feldspars, micas, and evolved melts. Ni, on the other hand, should behave like Mg and concentrate in olivine, and other early-forming mafic minerals.
2. If two ions have ***a similar radius and the same valence***, the ***smaller*** ion is preferentially incorporated into the *solid* over the liquid. Because Mg is smaller than Fe, it should be preferred in solids, as compared to liquids. This is clearly demonstrated by noting the Mg/Fe ratio in olivine vs. liquid in the Fo-Fa system. Mg/Fe is always greater in olivine than in the coexisting melt.
3. If two ions have a ***similar radius*** but ***different valence***, the ion with the ***higher*** *charge* is more ***readily*** incorporated into the *solid* over the liquid. Thus Cr^{+3} and Ti^{+4} are almost always preferred in solids as compared to liquids.

d) Alumina (Al_2O_3) Saturation

After silica, alumina is the second most abundant oxide constituent in igneous rocks. Feldspars are, in general, the most abundant minerals that occur in igneous rocks. Thus, the concept of alumina saturation is based on whether or not there is an excess or lack of Al to make up the feldspars. Note that Al2O3 occurs in feldspars in a ratio of 1 Al to 1 Na, 1K, or 1 Ca:

$KAlSi_3O_8$ -- $1/2K_2O : 1/2Al_2O_3$

$NaAlSi_3O_8$ -- $1/2Na_2O : 1/2Al_2O_3$

$CaAl_2Si_2O_8$ -- $1CaO : 1Al_2O_3$

Three possible conditions exist.

1. If there is an excess of Alumina over that required to form feldspars, we say that the rock is ***peraluminous***. This condition is expressed chemically on a molecular basis as:

Al2O3 > (CaO + Na2O + K2O)

In peraluminous. rocks we expect to find an Al2O3 rich mineral present as a modal mineral such as muscovite, corundum, topaz, or an Al2SiO5 mineral like kyanite, andalusite, or sillimanite.

Peraluminous rocks will have corundum in the CIPW norm and no diopside in the norm.

2. ***Metaluminous*** rocks are those for which the molecular percentages are as follows:

Al2O3 < (CaO + Na2O + K2O) and Al2O3 > (Na2O + K2O)

These are the more common types of igneous rocks. They are characterized by lack of an Al2O3 rich mineral and lack of sodic pyroxenes and amphiboles in the mode.

3. ***Peralkaline*** rocks are those that are oversaturated with alkalis (Na2O + K2O), and thus undersaturated with respect to Al2O3. On a molecular basis, these rocks show:

Al2O3 < (Na2O + K2O)

Peralkaline rocks are distinguished by the presence of Na rich minerals like aegirine, riebeckite, arfvedsonite, or aenigmatite in the mode.

e) An incompatible element

Incompatible elements are defined as those elements that partition readily into a melt phase when the mantle undergoes melting.

f) Physical changes in magma as it ascends

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during the ascending of magma these changes mostly occur:

a) Temperature Drops
   - a. Increase in viscosity
   - b. Crystallization begins
     - i. Increase in viscosity
     - ii. Composition becomes more silicic (more polymerized)
       - 1. Increase in viscosity
     - iii. Gases concentrated in melt

b) Pressure Drops
   - a. Gases exsolve
     - i. H_2O concentration drops
       - 1. Increase in viscosity
     - ii. Bubbles form
       - 1. Increase in viscosity

B. Write a summary of the differences (Geochemical characterization) between calc-alkaline and tholeiitic fractionation trends? (6 Marks)

Geochemical characterization

Rocks from the calc-alkaline magma series are distinguished from rocks from the tholeiitic magma series by the redox state of the magma they crystallized from (tholeiitic magmas are reduced, and calc-alkaline magmas are oxidized). When mafic (basalt-producing) magmas crystallize, they preferentially crystallize the more magnesium-rich and iron-poor forms of the silicate minerals olivine and pyroxene, causing the iron content of tholeiitic magmas to increase as the melt is depleted of iron-poor crystals. (Magnesium-rich olivine solidifies at much higher temperatures than iron-rich olivine.) However, a calc-alkaline magma is oxidized enough to (simultaneously) precipitate significant amounts of the iron oxide magnetite, causing the iron content of the magma to remain more steady as it cools than with a tholeiitic magma.

-Best Wishes-

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