UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2014/2015 Academic Session

June 2015

EBS 242/3 – Petrography and Ore Microscopy
[Petrografi dan Mikroskopi Bijih]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains SIXTEEN printed pages and TWO pages APPENDIX before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM BELAS muka surat dan DUA muka surat LAMPIRAN yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions. TWO questions in PART A and FIVE questions in PART B.
[Kertas soalan ini mengandungi TUJUH soalan. DUA soalan di BAHAGIAN A dan LIMA soalan di BAHAGIAN B.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A and **THREE** questions from PART B. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A dan **TIGA** soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies in the examination questions, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

PART A / *BAHAGIAN A*

1. Please define or describe the following:

[a] Based on the QAPF classification system (Appendix 1), determine the class/type and the name of these igneous rocks according to their respective composition and textures as given in Table A.

Berdasarkan sistem pengelasan QAPF (Lampiran 1), tentukan kelas/jenis serta nama batuan-batuan igneous yang mempunyai tekstur dan komposisi seperti yang diberikan dalam Jadual A.

Table A

Jadual A

Features *Fetur*	**Igneous A** *Igneus A*	**Igneous B** *Igneus B*	**Igneous C** *Igneus C*
Composition *Komposisi*	Q: > 23% AP: < 9% Plg: > 66% Acc: Muscovite (< 2%)	Q: 45% AP: 40% Plg: 10% Acc: Biotite	Q: 6% AP: < 24% Plg: > 65% Acc: Olivine (> 5%)
Texture *Tekstur*	Medium to coarse *Berbutir sederhana hingga kasar*	Coarse grained *Berbutir kasar*	Aphanetic *Afanetik*
Distinguished features *Sifat-sifat khas*	Granular *Berbutir*	Euhedral *Fenokris feldspar* Pink feldspar Phenocryst *berwarna merah jambu* Porphyritic *Porfiritik*	Lava flow *Aliran lava* Mafic *Mafik* Plagioclase lath *Bilah-bilah plagioklas*

Notes: Q: Quartz; AP: Alkaline feldspar; Plg: Plagioclase and Acc: Accessory mineral

Nota: K: Kuarza; AF: Alkali felspar; Plg: Plagioklas and Acc: Mineral aksesori

(50 marks/*markah*)

[b] Briefly discuss the differences between the properties of the following rocks (composition, texture, grain size and other distinguished features).

(i) Shale and Gneiss

(ii) Conglomerate and Hornfels

(iii) Limestone and tuff

Secara ringkas, bincangkan sifat-sifat perbezaan-persamaan utama di antara pasangan batuan berikut (komposisi, tekstur, saiz butiran dan fetur-fetur unggul lain)

(i) Syal dan Gneis

(ii) Konglomerat dan Honfels

(iii) Batu kapur dan tuf

(50 marks/*markah*)

2. Answer the following question

Sila jawab semua soalan berikut

[a] What is meant by the term "lithification"?

Apakah yang dimaksudkan dengan istilah "lithification"?

(10 marks/*markah*)

[b] Of the common elements that compose the minerals (that in turn compose the rocks) of the earth's crust, name 4 **elements** that in the weathering process tend to be carried away in **solution**. Where these elements do generally deposited?

Daripada elemen-elemen biasa yang membentuk mineral (juga membentuk batuan) dari kerak bumi, namakan empat elemen di dalam proses luluhawa yang cenderung untuk di bawa dalam larutan. Di mana elemen-elemen ini biasanya terenap?

(10 marks/*markah*)

[c] What is (in general) the origin of the **clay** that is such a large constituent of most "shales"?

Apakah (secara umum) asal-usul tanah liat yang menjadikannya konstituen yang paling besar dalam "syal"?

(10 marks/*markah*)

[d] What is (in general) the origin of the quartz that is so abundant in common sand deposits?

Apakah (secara umum) asal-usul kuarza yang begitu banyak terdapat dalam deposit pasir biasa?

(10 marks/*markah*)

[e] Rank the following minerals in order of increasing **resistance** to chemical weathering (place the least resistant on the left to most resistant to weathering on the right):

- Muscovite, calcic plagioclase, hornblende, biotite, quartz

Susun mineral berikut dalam arah peningkatan daya tahan terhadap luluhawa kimia (letakkan yang paling kurang tahan di sebelah kiri kepada paling tahan cuaca di sebelah kanan):

- *Muscovite, calcic plagioclase, hornblende, biotite, kuarza*

(10 marks/*markah*)

[f] Rank listed minerals in the order of the most **easily weathered** to the least easily weathered:

- Sodic plagioclase, alkali feldspar, clinopyroxene, olivine, hornblende

Letakkan senarai mineral dalam susunan yang paling mudah terluluhawa kepada kurangnya mudah terluluhawa:

- *Sodic plagioclase, alkali feldspar, clinopyroxene, olivine, hornblende*

(10 marks/*markah*)

[g] Sandstone A is said to be "well sorted", while sandstone B is said to be "poorly sorted". How would you **describe** the difference between sandstone A and B?

Batu pasir A dikatakan "terisih baik", manakala batu pasir B dikatakan "terisih buruk". Bagaimana anda gambarkan perbezaan di antara batu pasir A dan B?

(20 marks/*markah*)

[h] What is the difference between a mudstone and a siltstone?

Apakah perbezaan di antara batu lumpur dan batu lodak?

(10 marks/*markah*)

[i] What is the main difference between a breccia and a conglomerate? What factors can contribute to clast roundness?

Apakah perbezaan utama antara breksia dan konglomerat? Apakah faktor yang boleh menyumbang kepada klas yang membulat?

(10 marks/*markah*)

PART B / *BAHAGIAN B*

3. [a] Figure 1 (a) shows the formation charts or diagrams of the common rock classes or categories (Rock A) in the earth's crust. Discuss and elaborate about the formation scheme.

Carta atau gambarajah 1(a) yang diberikan menunjukkan skema pembentukan atau kategori bagi batuan pembentukan kerak bumi (Batuan A). Bincang dan perjelaskan skema pembentukan ini.

Rock A

Batuan A

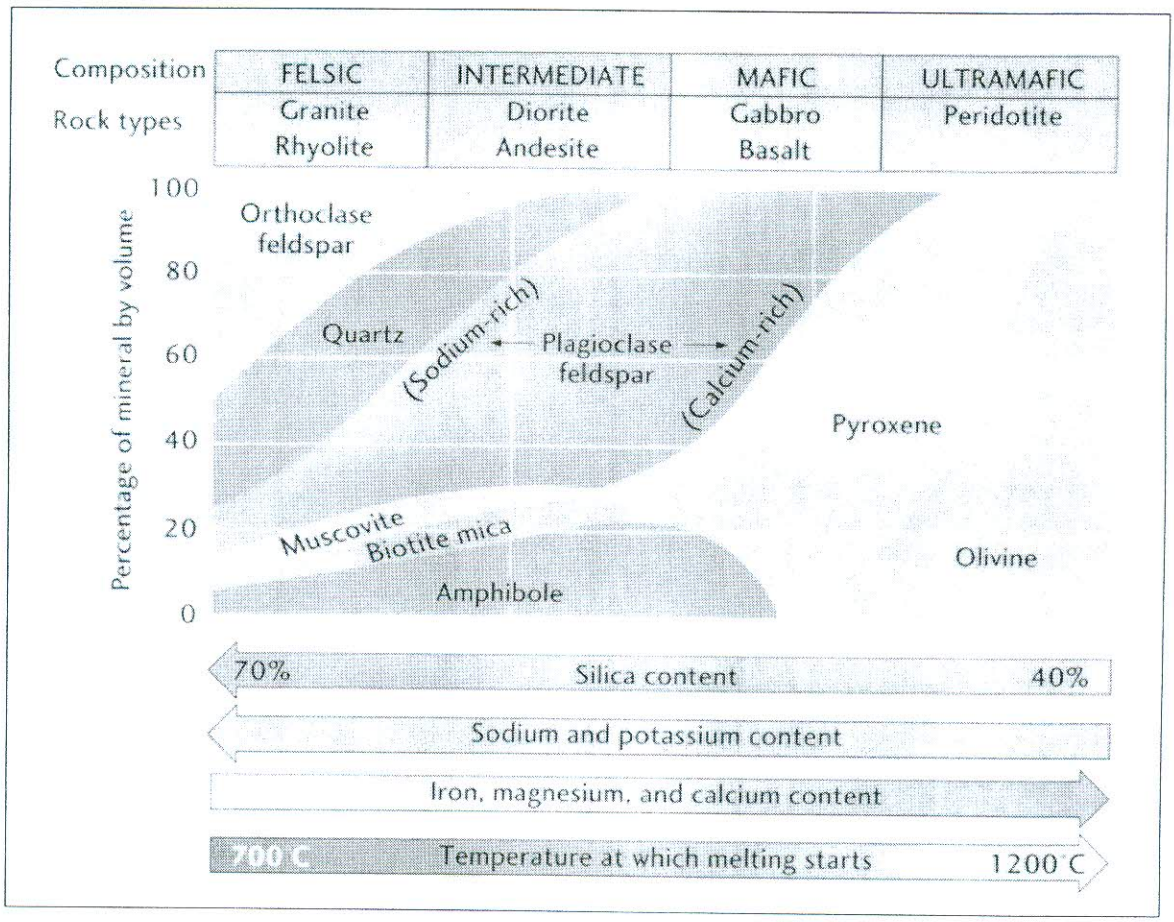


Figure 1 [a]

Rajah 1 [a]

(50 marks/*markah*)

[b] Define or describe the following:

(i) Relief and Becke Lines (optical mineralogy)

(ii) The relationship of *double refraction, velocities* and *refractive indices* when a narrow beam of light entering an isotropic crystal.

(iii) Opacity and Euhedral (in optical mineralogy)

(iv) Isotropism and Bireflectance (in ore microscopy)

(v) Reflected pleochroisme and internal reflection (in ore microscopy)

Takrif atau terangkan mengenai perkara-perkara berikut

(i) Jasad timbul dan garis Becke (Mineralogi erat)

(ii) Perhubungan di antara bias duaan, kelajuan dan indeks biasan apabila cahaya menembusi mineral bersifat ekapaksi

(iii) Legapan dan Euhedron (Mineralogi erat)

(iv) Isotrop dan Dwibalikan (Mikroskopi bijih)

(v) Pleokroisme pantulan dan pantulan dalaman (Mikroskopi bijih)

(50 marks/*markah*)

4. [a] How thin section of a mineral is prepared and subsequently examined under polarizing microscope?

Bagaimana eratin nipis bagi satu mineral itu disediakan dan seterusnya dikaji menggunakan mikroskop terkutub?

(40 marks/*markah*)

[b] The anisotropy shown by non-cubic crystals in their physical properties can also be shown by their absorption – this phenomenon is called pleochroisme and is a useful distinguishing property. Define and how such property is determined under polarizing microscope?

Sifat tak isotrop satu mineral bukan kiub yang ditunjukkan melalui sifat fizikal juga dapat dilihat melalui sifat serapannya – fenomena ini disebut sebagai pleokroisme dan sifat yang penting di dalam mengenali sesuatu mineral. Beri keterangan mengenai ciri ini dan bagaimana ia dikenalpasti di bawah mikroskop terkutub?

(30 marks/*markah*)

[c] Optical mineralogy is a study of the interaction of light with minerals, most commonly limited to visible light and usually further limited to the non-opaque minerals. With appropriate illustrations show the polarization process of an ordinary light transmitting through the polarizing microscope.

Mineralogi optik adalah pengkajian berkaitan hubungan antara cahaya dan mineral, yang kebiasaannya terhad kepada cahaya yang boleh dilihat dan lebih terhad kepada mineral bijih. Dengan menggunakan carta yang sesuai, tunjukkan proses pengutuban cahaya apabila ia menembusi mikroskop terkutub.

(30 marks/*markah*)

5. [a] Describe briefly how recrystallization and/or new mineral growth interact with tectonic stresses to produce foliation in a metamorphic rock.

Terangkan secara ringkas bagaimana penghabluran semula dan/atau pertumbuhan mineral baru berinteraksi dengan tekanan tektonik untuk menghasilkan foliasi dalam batu metamorf.

(20 marks/*markah*)

[b] What is the difference between "recrystallization" and "neomineralization"?

Apakah perbezaan di antara "penghabluran semula" dan "neomineralization"?

(20 marks/*markah*)

[c] What is a granoblastic texture?
Apakah tekstur granoblas?

(10 marks/*markah*)

[d] Rocks with **what kind of minerals** tend to form granoblastic textures under metamorphic conditions?

- Rocks with minerals that tend to form equant grains
- Rocks with minerals that tend to form platy grains
- Rocks with minerals that tend to form prismatic grains
- Rocks with minerals that tend to form acicular or fibrous grains

Batuan dengan ***mineral apakah cenderung*** *untuk membentuk tekstur granoblastik di bawah syarat proses metamorfisme?*

- *Batuan dengan mineral yang cenderung untuk membentuk butiran equant*
- *Batuan dengan mineral yang cenderung untuk membentuk butiran berkeping*
- *Batuan dengan mineral yang cenderung untuk membentuk butiran prisma*
- *Batuan dengan mineral yang cenderung untuk membentuk butiran jejarum atau berserabut*

(10 marks/*markah*)

[e] Quite often that, in mica schists, staurolite or garnet, if present, occurs as porphyroblasts, giving the rock a porphyroblastic texture.

What are "porphyroblasts"?

Menjadi kebiasan di dalam syis mika, staurolite atau garnet, jika hadir, wujud sebagai porfiroblas, menjadikan batu tersebut bertekstur porfiroblastik.

Apakah porfiroblas?

(10 marks/*markah*)

[f] Define contact metamorphism? Where does it usually take place? How large an area is generally affected by contact metamorphism?

Jelaskan metamorfisme sentuh? Di manakah ia biasanya berlaku? Bagaimana besar kawasan biasanya dipengaruhi oleh metamorfisme sentuh?

(10 marks/*markah*)

[g] Name two minerals that crystallize only at relatively low pressures with high temperatures, thus making them common features of rocks affected by contact metamorphism.

Namakan dua mineral yang terbentuk hanya pada tekanan yang rendah dan suhu yang tinggi, sekali gus menjadikan mereka batu yang biasa terjejas melalui metamorfisme sentuh.

(20 marks/*markah*)

6. [a] Determine the type or name of the following igneous rock specimen marked **A** to **E**, as observed under the microscope petrographic as given in the table below.

*Tentukan jenis atau nama spesimen batuan igneus berikut yang bertanda **A** hingga **E** sebagaimana diperhatikan di bawah mikroskop petrografik seperti di dalam jadual di bawah.*

Rock *Batuan*	**Colour/Texture** *Warna/Tekstur*	**Composition** *Komposisi*	**Key texture** *Tesktur utama*
A	Dark, dense and homogeneous *Gelap, padat dan homogen*	Easily split to chonchoidal form *Mudah terpecah kepada bentuk konkoidal*	Holohyaline *Holohialin*
B	Bright colour/ Coarse grained *Berwarna cerah/Berbutir kasar*	Q = 40% Plg = 30% *K = 40%* *Plg = 30%*	Details anhedral quartz surrounded by biotite and a little muscovite *Butiran anhedral kuarza yang dikelilingi oleh biotit dan sedikit muskovit*
C	Dark, Ultramafic/ Coarse grained *Gelap, Ultramafik, Berbutir kasar*	M = 90% Plg = <5% *M = 90%* *Plg = <5%*	Overall consists of crystals not uniform grain size and high of birefringence olivine, little chlorite and other opaque minerals *Keseluruhan terdiri daripada hablur ketidaksama butiran dan dwirefringen tinggi olivine, sedikit klorit dan mineral legap lain*
D	Dark/ Coarse grained *Gelap, Berbutir kasar*	K = <5% Plg = 70% *K = <5%* *Plg = 70%*	Content blade calcite high plagioclase (An> 50%). Common occurrence with little olivine augite. *Kandungan bilah plagioklas kalsik yang tinggi (An>50%). Kejadian olivine yang lumrah dengan sedikit augit.*
E	Medium colour/ Coarse grained *Pertengahan, Berbutir kasar*	K = 15% Plg = 90 – 100% *K = 15%* *Plg = 90 – 100%*	Intrusion, subhedral plagioclase-rich, appear in a matrix of fine-grained plagioclase, volcanic material glassy clinopyroxene *Trobosan, kaya plagioklas subhedral, kelihatan dalam suatu matrik berbutir halus plagioklas, klinopiroksin bahan volkanik bergelas*

(50 marks/*markah*)

...14/-

[b] Explain the following:

(i) What is the relationship between birefringence and interference colors? Explain with the help of diagram.

(ii) "Texture" which describe about the fabric and grain size nature of igneous rocks is an important criteria in naming these rocks. Please define or briefly describe the following "textures" that typify igneous rocks.

- Holocrsytalline and hypocrystalline
- Phenocystalline and porphyritic
- Crystal shapes

Terangkan yang berikut:

(i) Apakah hubungan antara dwibiasan dan gangguan warna? Terangkan dengan bantuan gambarajah

(ii) "Tekstur" yang menjelaskan mengenai tabii fabrik dan saiz butiran yang terdapat pada batuan igneous adalah kriteria penting dalam penamaan batuan ini. Takrifkan atau secara ringkas terangkan pengertian "tekstur" yang mencirikan batuan igneous.

- *Holokristalin dan hipokristalin*
- *Fenokristalin dan porforitik*
- *Bentuk-bentuk hablur*

(50 marks/*markah*)

7. [a] Ore microscopy study is a technique that can provide valuable information that will help mineral processing engineer in mineral extraction process design. Discuss such valuable information and its consequence.

Kajian mikroskopi bijih adalah satu teknik yang boleh memberikan maklumat yang berharga yang boleh membantu jurutera pemprosesan mineral dalam mineral reka bentuk proses pengekstrakan. Bincangkan apa-apa maklumat yang berharga dan akibatnya.

[b] Please discuss the following:

(i) How hardness is measured in petrographic study of ore minerals? The discussion should be based on the relative and qualitative method of measuring.

(ii) What is bireflectance and reflectance pleochroism? How the bireflectance and reflectance pleochroism of a mineral is determined in ore petrographic study?

Sila beri keterangan atau penjelasan mengenai perkara berikut:

(i) Bagaimanakah kekerasan satu mineral diukur di dalam petrografi mineral bijih? Perbincangan hendaklah berasaskan kepada kaedah pengukuran relatif dan kualitatif.

(ii) Apakah itu pantulan dalaman dan dwibalikan pleokroisme? Bagaimanakah sifat balikan dikenalpasti di dalam petrografi mineral bijih?

[c] State some of the metallic minerals (mineral assemblage) optical properties that differentiate:

(i) Pyrite, bornite, chalcopyrite and covellite (in porphyry copper)

(ii) Gold, pyrite, galena and quartz (in gold-bearing quartz vein)

(iii) Magnetite, hematite and quartz (Iron ore)

Nyatakan beberapa mineral logam (himpunan mineral) sifat optik yang membezakan:

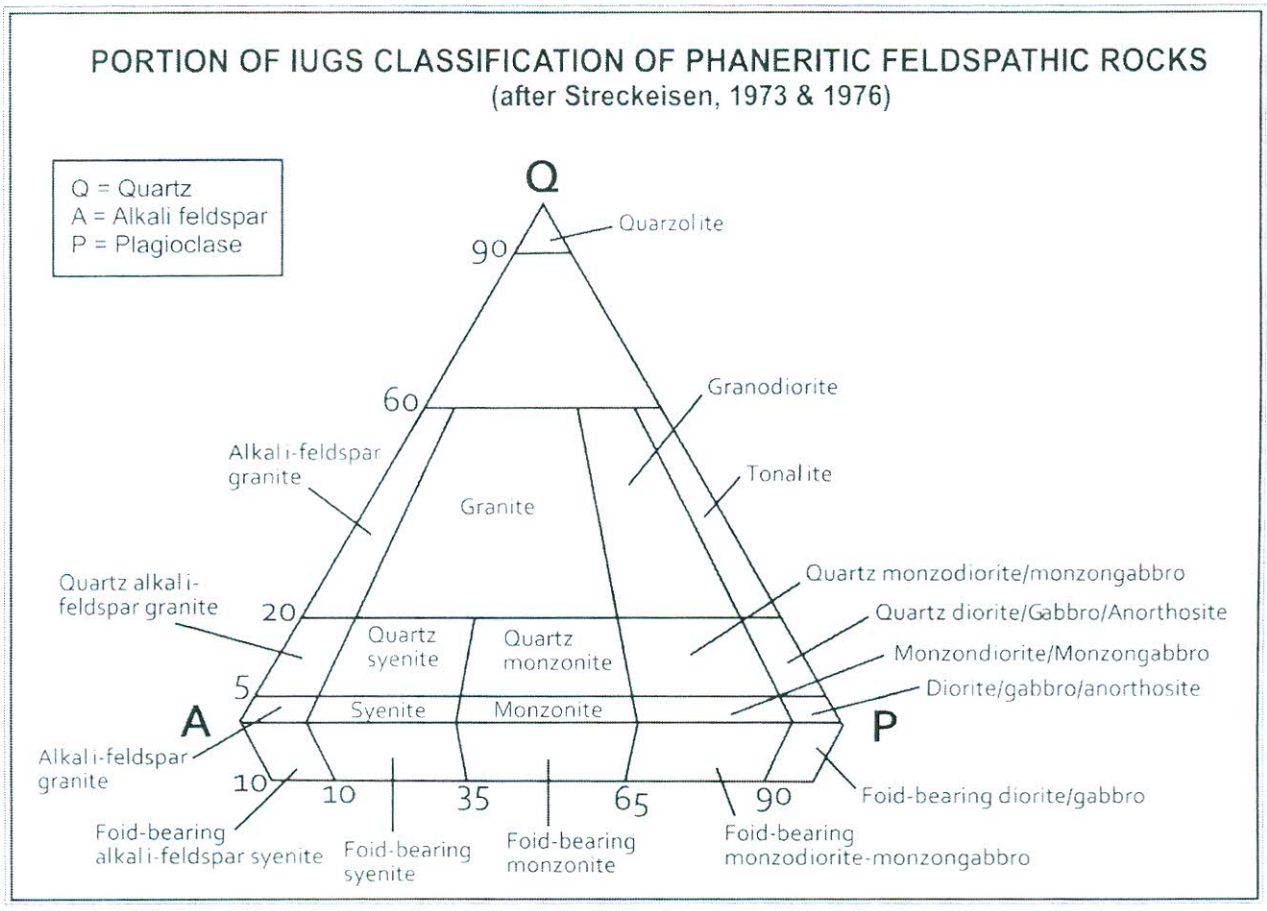
(i) Pirit, bornite, kalkopirit dan kovelit (tembaga porfiri)

(ii) Emas, pirit, galena dan kuarza (dalam urat- emas kuarza)

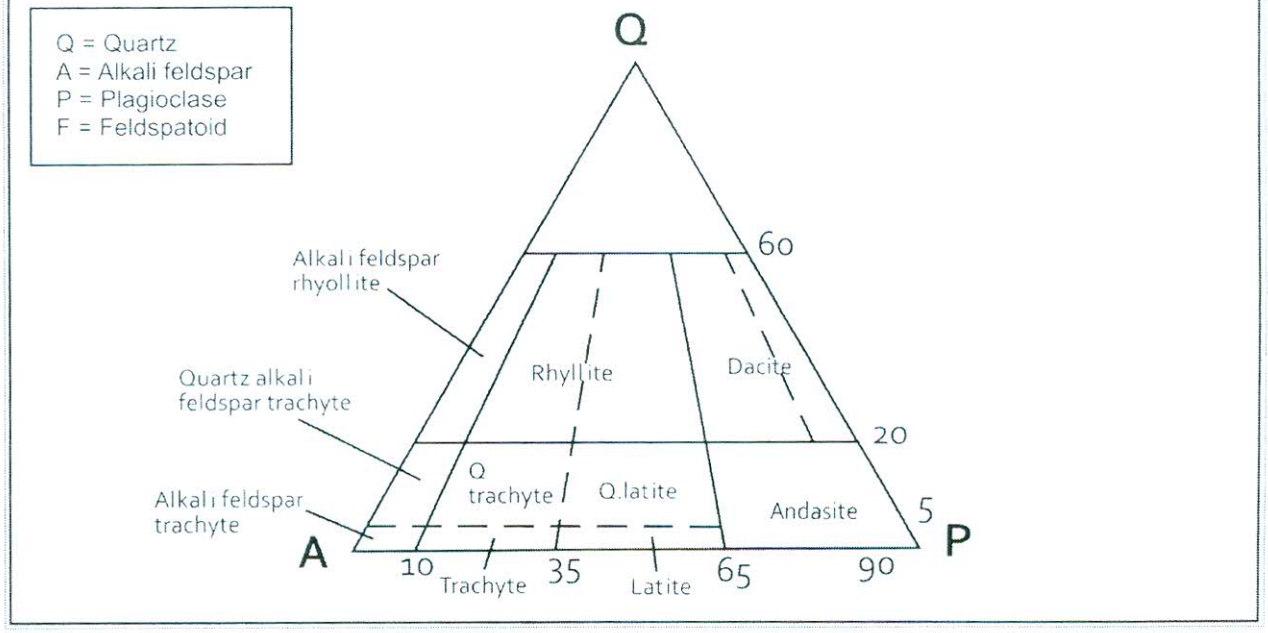
(iii) Magnetit, bijih besi dan kuarza (bijih besi)

(100 marks/*markah*)

APPENDIX I / *LAMPIRAN I*



IUGS CLASSIFICATION OF VOLCANIC ROCKS (<90% mafic; after Streckeisen, 1979)



IUGS CLASSIFICATION OF VOLCANIC FELDSPATHIC ROCKS
(<90% mafic; after Streckeisen, 1979)