Igneous & Metamorphic Petrology (GEOL2231)

Assessment: Igneous Petrology and geochemistry

Due: 26th February – 5pm – hand in to the main office

Outline:

A geologist has collected rock samples from three different volcanoes. They have undertaken geochemical and petrological analyses of the samples, including:

1) Major element compositions
2) Trace element compositions
3) $^{87}Sr/^{88}Sr$ and $^{143}Nd/^{144}Nd$ isotopes
4) Petrologic analyses (including some microprobe analyses)

You have been provided with copies of their data (tables and figures available on DUO).

Unfortunately, they have mixed up all their data and no longer know which analyses come from which volcanoes.

Your task is to analyse the different data-sets and work out which samples belong together, and which location each came from. Record your answers in the summary table at the end of this handout.

You must give a brief account of the type of magmatism and processes that have generated each suite of rocks, and provide reasons for your decisions.

It is easiest to analyse the chemical data using Excel, but if you wish to plot them by hand on the diagrams provided here (available on DUO) you can.
You will need to integrate all your results in order to fully interpret all the data.
Use the material covered in lectures and practicals from weeks 10-15 to help you.

Details:

1) Location data:

The geologist has recorded four different locations:

Site Number	Longitude	Latitude	Tectonic setting
Site 1	28°18'53.5"N	16°37'57.2"W	
Site 2	1°05'54.8"N	20°13'11.0"W	
Site 3	54°46'41.4"N	1°35'04.2"W	
Site 4	15°30'27.4"N	61°21'47.0"W	

i) **Use Google Maps/Earth to locate each field site**
ii) **Determine what the tectonic setting is at each field site**
   - Think about the type of volcanism you would expect to find at each site (if any) – this will help you locate your rock samples once you have classified them according to their chemistry.

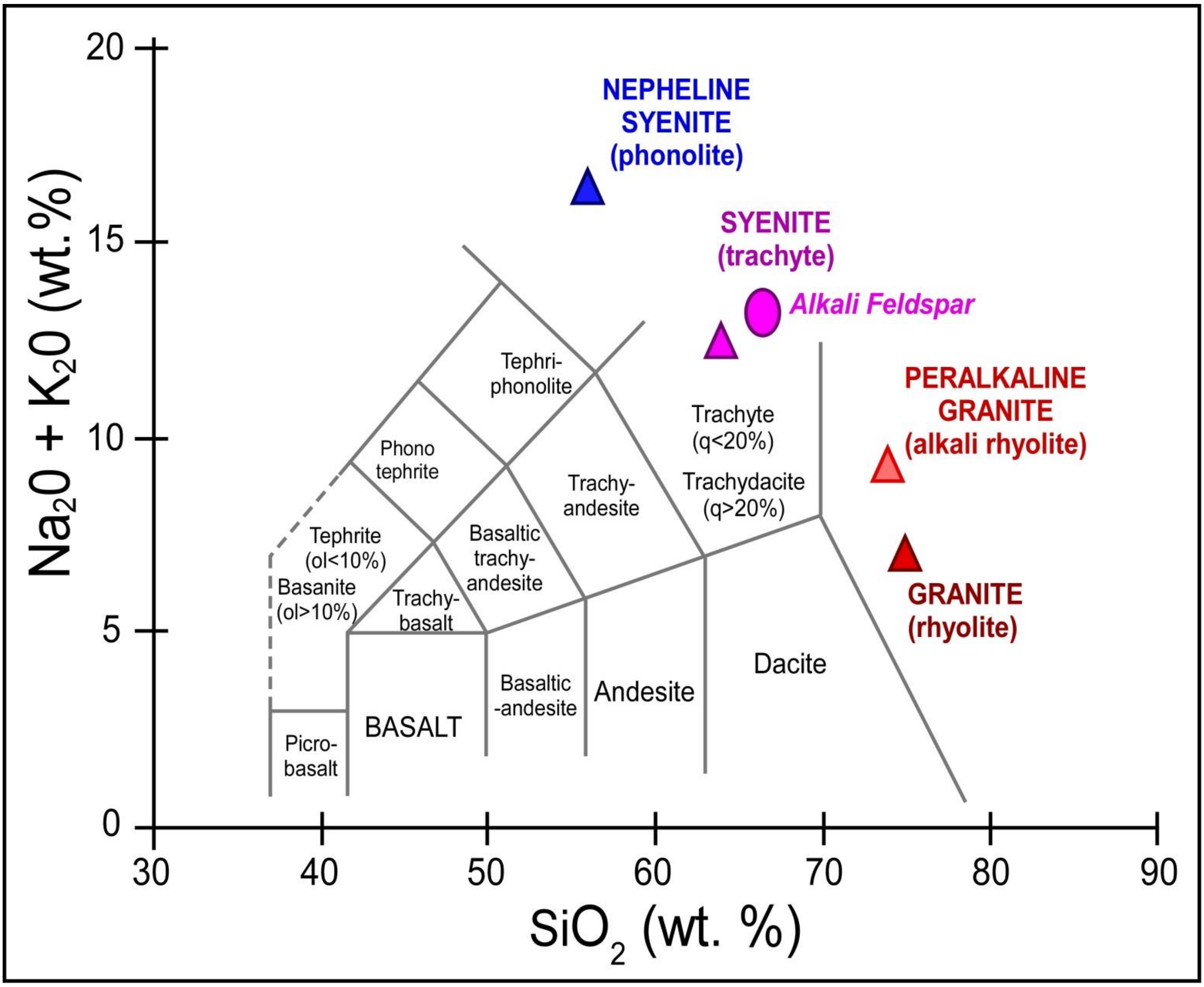
2) Major element geochemistry:

XRF whole rock analyses were performed on each rock sample to determine their major elemental compositions. These data are presented in tables 1-3.

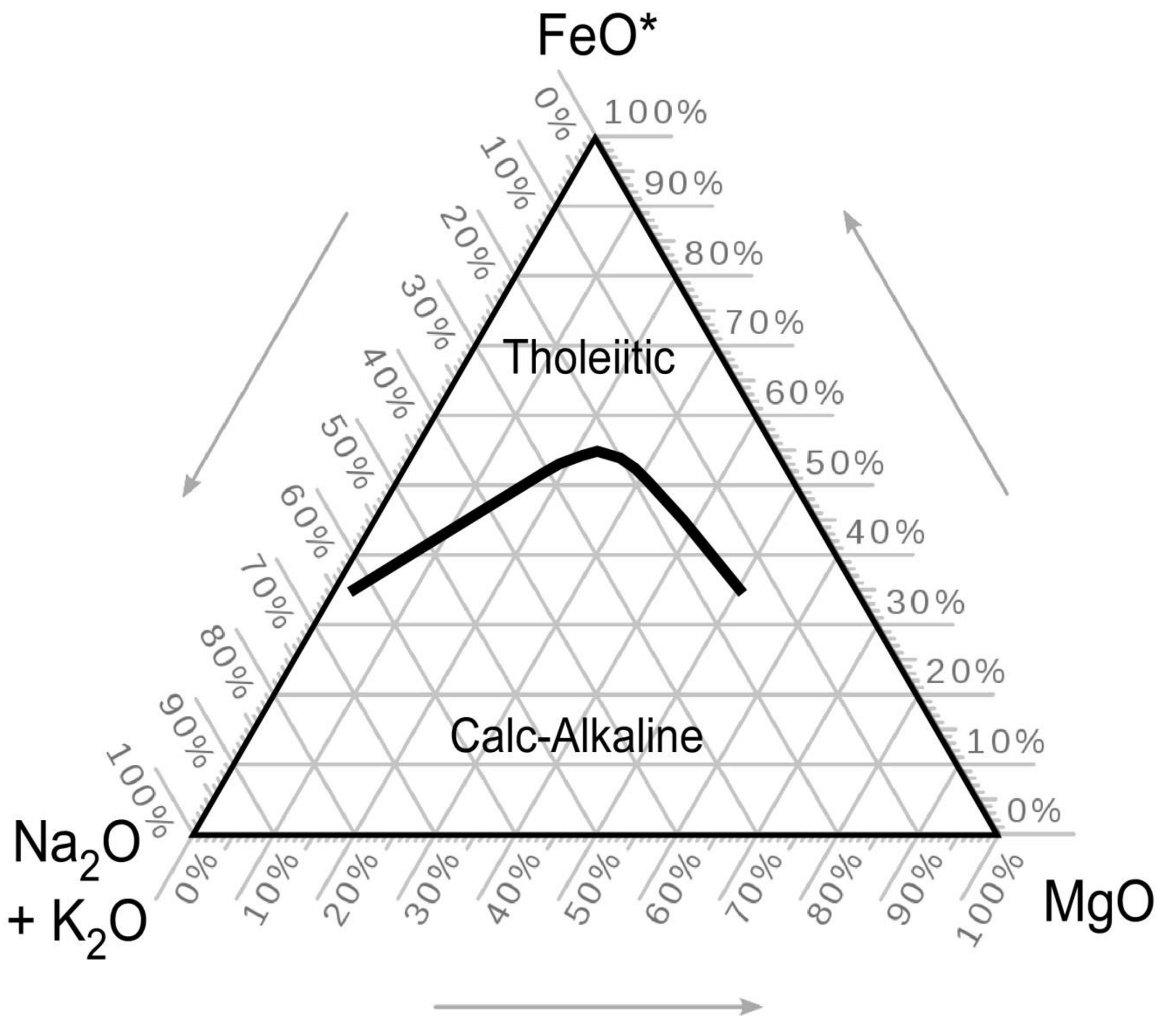
Table 1: sample suite A
Table 2: sample suite B
Table 3: sample suite C

You must classify the samples by using their major element chemistry data, and in turn determine which type of volcanic setting (and field site) each suite most likely came from.
Ways that you can do this are suggested below – but you can also analyse the data in additional ways if you think it could help you.

i) **Create a TAS (Total-Alkali-Silica) diagram for each data-set to determine the type of parental magma.**
   - You can plot each sample suite on the same graph to aid comparison
   - Compare your results with the TAS plot below
   - What are the compositions of the rock samples?
   - Do the samples indicate a tholeiitic or alkaline source?
   - What type of magmatic setting might account for these volcanic suites?
   - Can you determine the volcanic setting of all three suites from a TAS plot alone?



Tholeiitic and Calc-alkaline magmas can be difficult to distinguish using a TAS plot. Better ways to distinguish these suites are with plots of **FeO/MgO vs Silica**, and **AFM ternary diagrams**.



ii) To plot an AFM (Alkali-FeO-MgO) ternary diagram – you can use the "tri-plot Excel spreadsheet" provided on DUO.

- Use the 'SIZE' sheet (third tab).
- Class 1= FeO, Class 2 = MgO, Class 3 = Alkalis.
- Enter your data in columns B (FeO), C (MgO) and D (Alkalis) → the ternary plot will automatically update with your data.
- You can copy and paste one ternary plot into another, to show multiple data sets as separate series on the same diagram.
- You can also copy the diagram as an image and import it to Inkscape or Powerpoint, where you can overlay different plots for comparison.
– If you export the diagrams as images - you can also then overlay them on the blank AFM diagram to help you classify the sample suites.

REMEMBER! First you will need to convert the FeO, MgO and Alkali values into <u>relative percentages</u>:

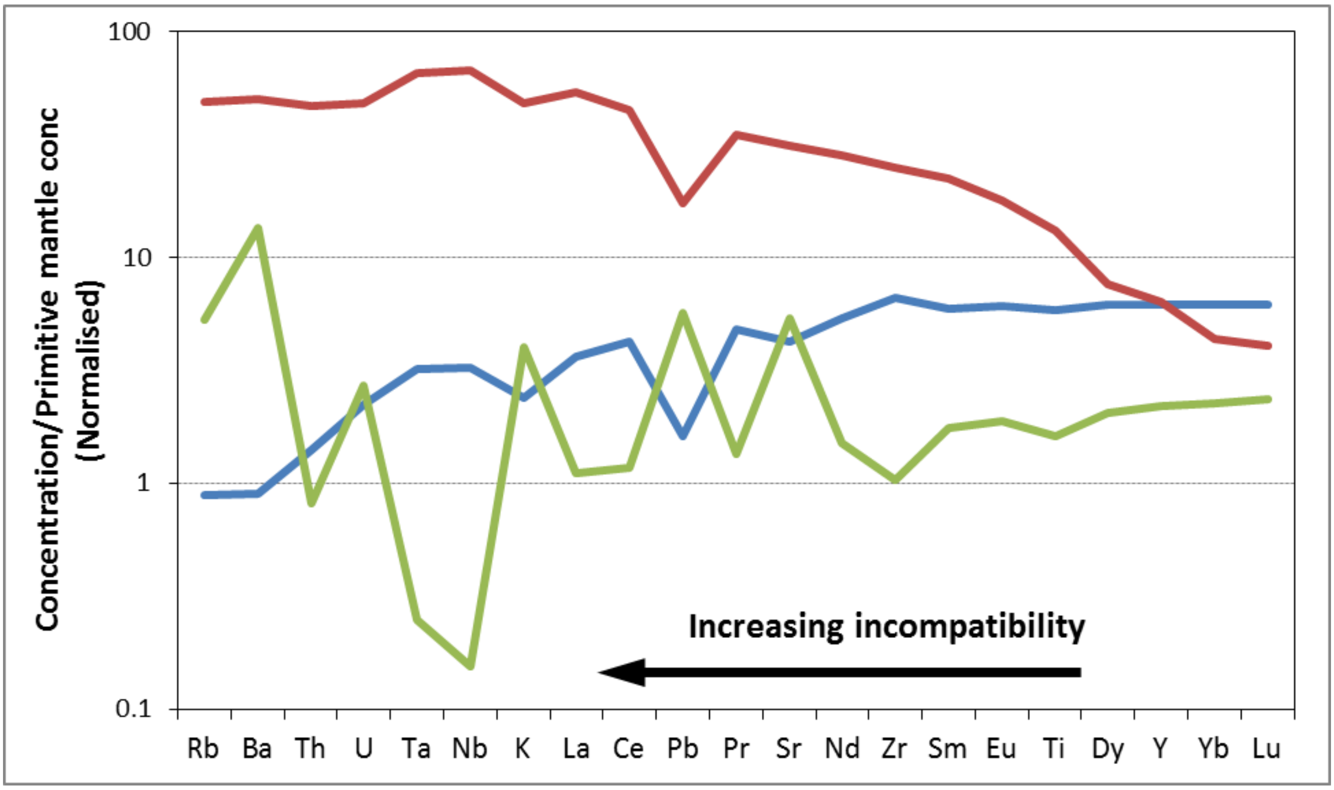
- Relative % = ("sample wt % value" / "Sum of A+F+M sample wt % values") x 100
- e.g. (Value of FeO in sample / Total values of A+F+M in sample) x 100 = rel % of FeO
- e.g. Rel % FeO = (10.4 / (10.4 + 7.5 + 2.98)) x 100 = 49.8%

3) Trace element geochemistry:

Trace element data was also obtained for one rock from each of the volcanic sample suites
= Samples: X, Y and Z.
This data is provided in **Table 4** – together with values for the composition of primitive mantle.

The plot below shows the primitive mantle-normalised concentrations for trace elements for each sample.

i) **Which line on the plot corresponds to each sample (X, Y and Z)?**
- You will need to calculate the mantle-normalised concentration for each sample.
- Normalised concentrations are simply the concentration in the sample divided by the concentration in the primitive mantle.



Circle correct answer:

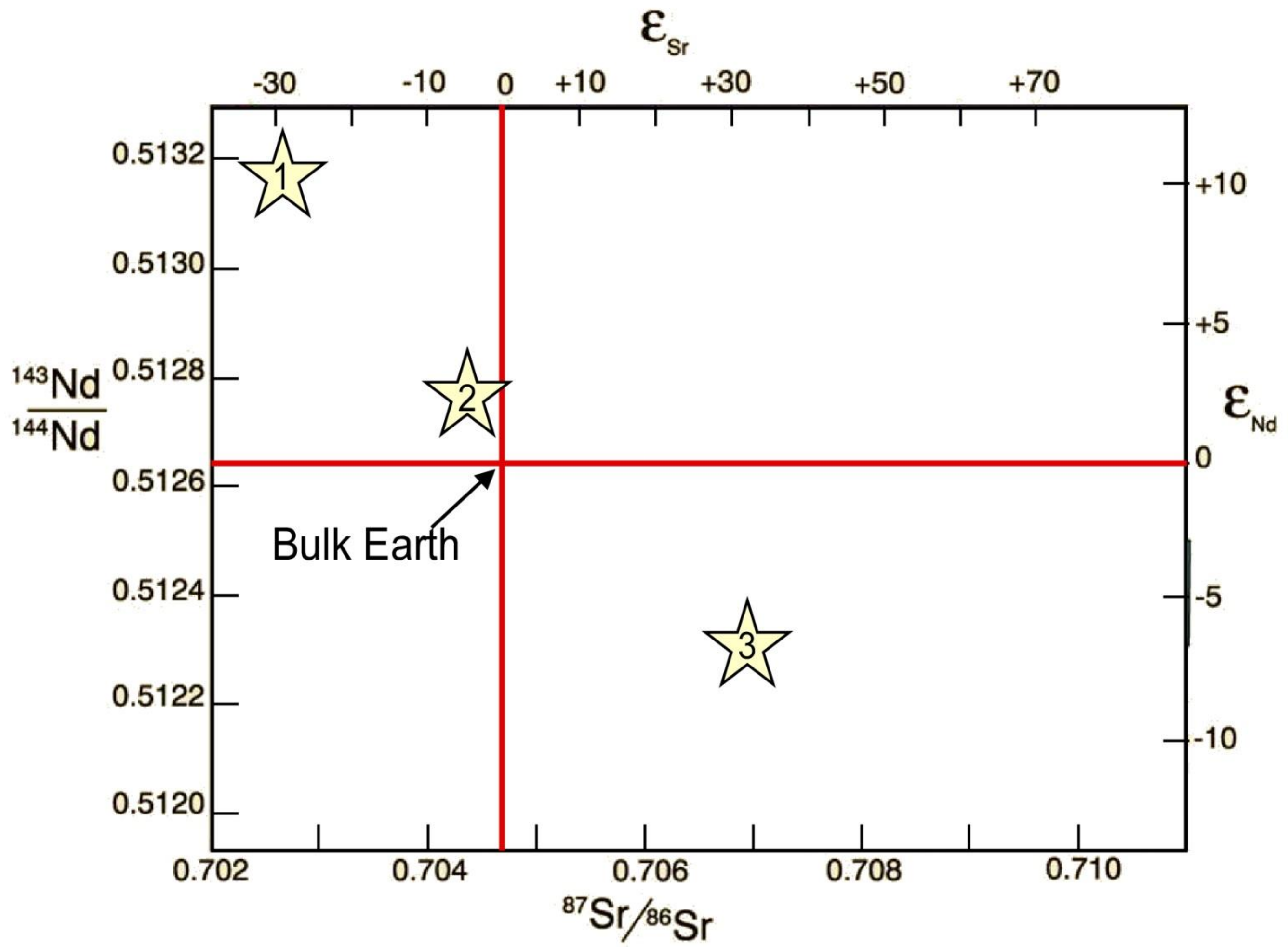
Sample X = red/blue/green line
Sample Y = red/blue/green line
Sample Z = red/blue/green line

ii) **Can you determine the tectonic setting of each sample from its pattern on the spider-diagram?**
- Use this to link samples X, Y and Z with your other data-sets.

4) Isotope geochemistry:

$^{87}Sr/^{88}Sr$ and $^{143}Nd/^{144}Nd$ isotope data was also obtained from the three sample suites. The average value for each sample suite has been plotted on the diagram below:

= stars 1, 2 and 3.



i) **Using the other data-sets to help you – determine which star (1, 2, 3) most likely corresponds to which volcanic sample suite.**
- think about the parental magma source and compositions of the different sample suites
- think about the tectonic setting of each sample suite
- which samples are most likely to be enriched/depleted relative to a bulk-Earth composition?

5) Thin section analyses and Microprobe data

The final data-set collected is from thin-section analyses of some rocks from each volcanic sample suite.

The geologist looked at thin sections under a polarising microscope, in XPL and PPL and -recorded - some helpful observations and sketches from their observations.

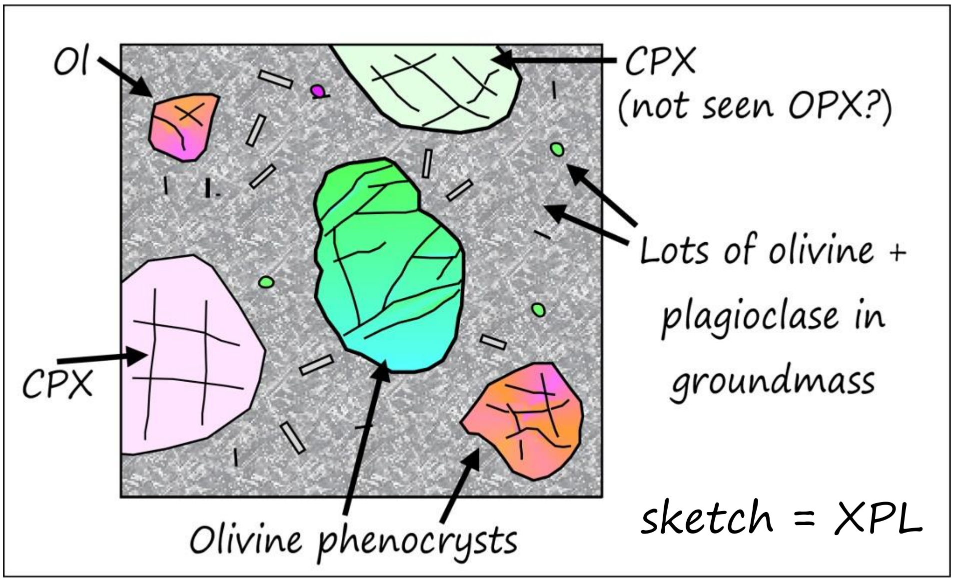
They also conducted some microprobe analyses to determine the Anorthite number of some Plagioclase phenocrysts, and the Magnesium number of some Olivine phenocrysts.

- Plagioclase evolves from calcium rich (high An #) to more sodium-rich (low An #) compositions.
- Olivine evolves from magnesium-rich (high Mg #) to more Fe-rich (lower Mg #) compositions.

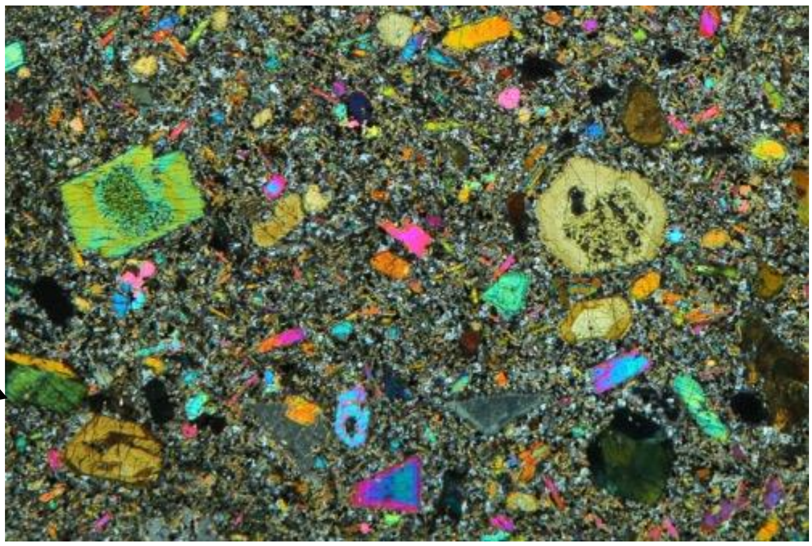
This data is provided below.

i) **Using the descriptions, sketches and microprobe analyses – determine which set of notes corresponds to each of the three volcanic sample suites.**

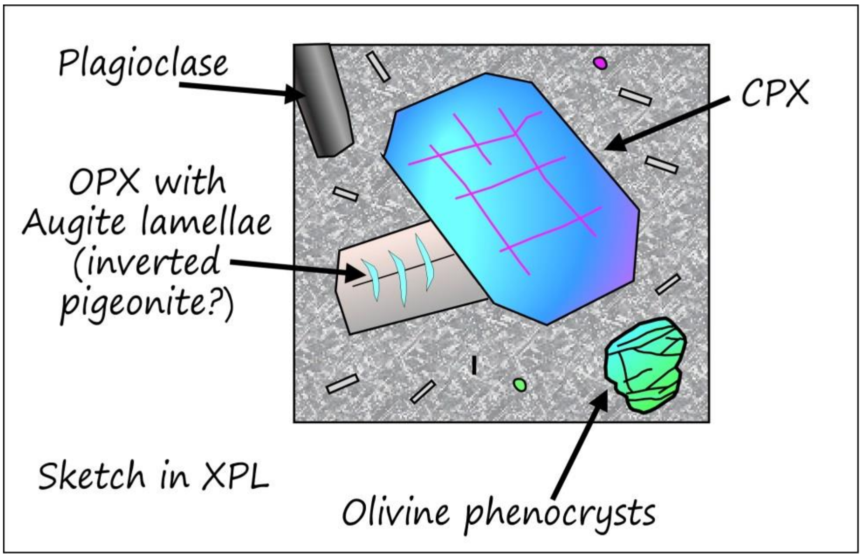
Set of thin section notes (a):



More evolved phenocrysts in this sample



Set of thin section notes (b):

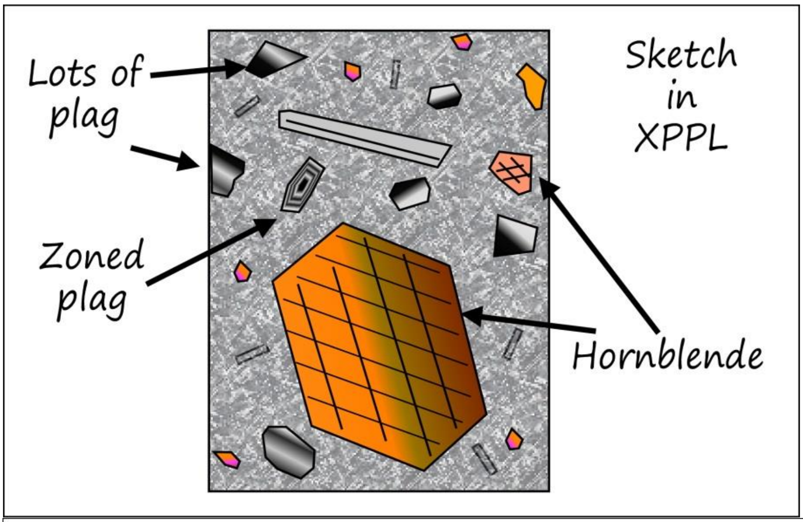


MICROPROBE DATA:

Plagioclase: An_{89-74}

Olivine: Mg_{92-75}

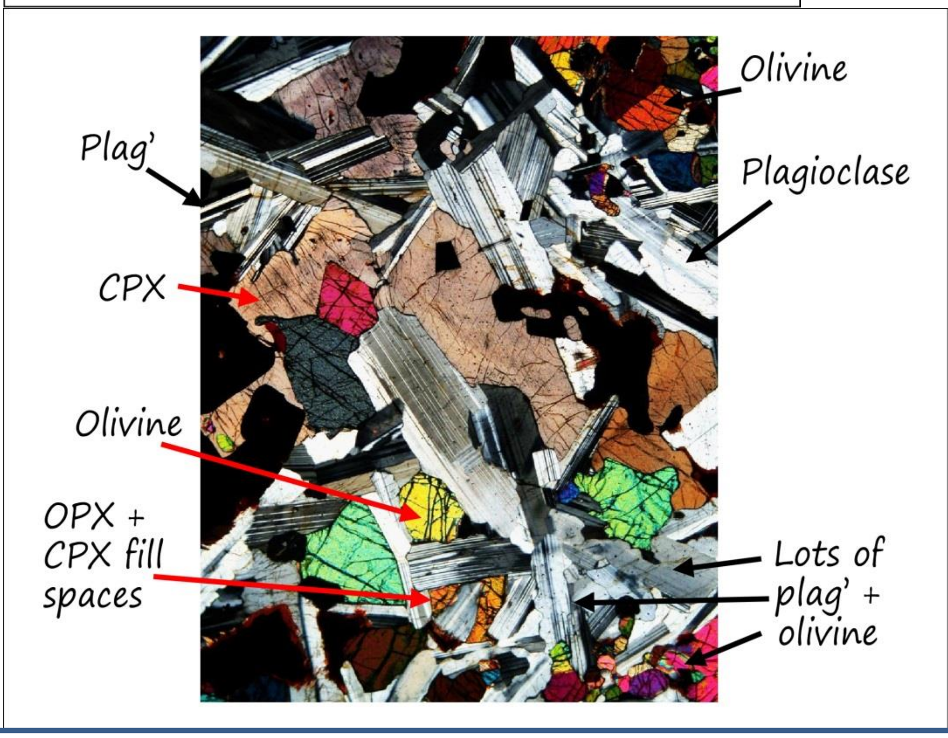
Set of thin section notes (c):



MICROPROBE DATA:

Plagioclase: An_{85-93}

Olivine: Mg_{75-69}



SUMMARY TABLE

Using all your observations and analyses from the 5 data-sets provided above, complete the following summary table:

Data-set 1		Data-set 2	Data-set 3	Data-set 3	Data-set 4	Data-set 5
Location	**Tectonic & Magmatic set-ting**	**Major element geochemistry data-set (A, B or C)**	**Trace element geochemistry data-set (X, Y or Z)**	**Line colour on trace element spider-diagram (red/blue/green)**	**Sr/Nd Isotope data (Star 1, 2 or 3)**	**Petrological data notes (a, b or c)**
Site 1						
Site 2						
Site 3						

SUMMARY OF DATA AND INTERPRETATION

Provide a brief account of the type of magmatism and processes that have generated each suite of rock samples, and provide reasons for your decisions based on the data-sets analysed.

SITE 1

SITE 2

SITE 3