## Practical 2: 15 Feb. 2006 CIPW norms: Linking chemistry and mineralogy

## I. Manual calculations of CIPW norms

Using the attached procedure and table, calculate CIPW norms for the following two samples:

|  | Sample 1 | Sample 2 |
| :--- | :--- | :--- |
| $\mathrm{SiO}_{2}$ | 61.52 | 51.7 |
| $\mathrm{TiO}_{2}$ | 0.73 | 0.9 |
| $\mathrm{Al}_{2} \mathrm{O}_{3}$ | 16.48 | 19.3 |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | 1.83 | 1.1 |
| FeO | 3.82 | 4.8 |
| MnO | 0.08 | 0.2 |
| MgO | 2.80 | 1.1 |
| CaO | 5.42 | 4.1 |
| $\mathrm{Na}_{2} \mathrm{O}$ | 3.63 | 8.9 |
| $\mathrm{~K}_{2} \mathrm{O}$ | 2.07 | 4.6 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 0.25 | 0.30 |

Explain why it is not possible to have both quartz and olivine, or quartz and feldspathoids, in the same rock.

## II. Norms and minerals

Use now the excel file available to you, either on the computer in the prac. room or on webCT (cipw-simple.xls). This file allows you to calculate norms for reasonable compositions (don't expect it to work perfectly for "weird" compositions, though). Enter the major elements composition at the top ("bulk analysis", yellow) and read the results in the weight proportion area (green).

## A. Exploring the relations between chemistry and (normative) mineralogy

(based on a problem by J.D. Winter, p.152)

1. Calculate a norm using the composition below (a average basalt), and note the resulting normative minerals. Determine the plagioclase composition. Is this mineralogy consistent with a basalt?
2. Now vary the silica content in successive $1 \%$ increments between 46 and $52 \%$. Explain the effects it has on normative minerals.
3. Return to your initial SiO 2 value, and vary Al 2 O 3 between 14 and $19 \%$. Explain the effects on the norm.
4. Return again to your original value, and increase Na 2 O from 1 to $5 \%$. Explain the changes.
5. Then, do the same for K2O.

|  | Basalt |
| :--- | :--- |
| $\mathrm{SiO}_{2}$ | 49.2 |
| $\mathrm{TiO}_{2}$ | 0.19 |


| $\mathrm{Al}_{2} \mathrm{O}_{3}$ | 15.7 |
| :--- | :--- |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | 3.79 |
| FeO | 7.13 |
| MnO | 0.20 |
| MgO | 6.73 |
| CaO | 9.47 |
| $\mathrm{Na}_{2} \mathrm{O}$ | 2.91 |
| $\mathrm{~K}_{2} \mathrm{O}$ | 1.10 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 0.05 |

## B. The silica saturation line

On the basis of their normative composition, rocks can be regarded as silica oversaturated (normative quartz) or silica undersaturated (normative olivine and/or foids).

1. By trial and error, draw on a TAS diagram the silica oversaturation line between 45 and $55 \% \mathrm{SiO} 2$, labeling the field you define. Change only the alkalis and silica values (keeping $\mathrm{Na} 2 \mathrm{O}=\mathrm{K} 2 \mathrm{O}$ ), and use the values of question A above for the other components, assuming they do not change (a stupid assumption, obviously).
2. Explain why this assumption is stupid
3. Explain why the differenciated terms of alkaline series are feldpathoid-bearing (and plot in the lower part of the QAPF).

## C. Norms and magmatic series

1. Plot the analysis in the following tables on a TAS and an AFM diagram, and indicate the magmatic series each table represents (you can use the file tas.xls from webCT).
2. Give the (IUGS, using TAS) name for each analysis
3. Calculate the normative mineralogy for each sample; use it to put it on a QAPF diagram (which you shouldn't do, in theory, since a QAPF is designed for modal, not normative, mineralogies).
4. On a QAPF diagram, qualitatively draw "trends" corresponding to the main magmatic series
5. Indicate the typical normative mineral associations in each of the main magmatic series

## Series A

|  | A 1 | A 2 | A 3 | A 4 |
| :--- | ---: | ---: | ---: | ---: |
| $\mathrm{SiO}_{2}$ | 41.60 | 44.30 | 54.99 | 56.19 |
| $\mathrm{TiO}_{2}$ | 2.66 | 2.51 | 0.60 | 0.62 |
| $\mathrm{Al}_{2} \mathrm{O}_{3}$ | 14.33 | 14.70 | 20.96 | 19.04 |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | 5.48 | 3.94 | 2.25 | 2.79 |
| FeO | 6.17 | 7.50 | 2.05 | 2.03 |
| MnO | 0.26 | 0.16 | 0.15 | 0.17 |
| MgO | 6.39 | 8.54 | 0.77 | 1.07 |
| CaO | 11.89 | 10.19 | 2.31 | 2.72 |
| $\mathrm{Na}_{2} \mathrm{O}$ | 4.79 | 3.55 | 8.23 | 7.79 |
| $\mathrm{~K}_{2} \mathrm{O}$ | 3.46 | 1.96 | 5.58 | 5.24 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 1.07 | 0.74 | 0.13 | 0.18 |

Series B

|  | B 1 | B 2 | B3 | B4 | B5 |
| :--- | ---: | ---: | ---: | ---: | ---: |
| $\mathrm{SiO}_{2}$ | 57.94 | 65.55 | 68.65 | 71.30 | 72.82 |
| $\mathrm{TiO}_{2}$ | 0.87 | 0.60 | 0.54 | 0.31 | 0.28 |
| $\mathrm{Al}_{2} \mathrm{O}_{3}$ | 17.02 | 15.04 | 14.55 | 14.32 | 13.27 |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | 3.27 | 2.13 | 1.23 | 1.21 | 1.48 |
| FeO | 4.04 | 2.03 | 2.70 | 1.64 | 1.11 |
| MnO | 0.14 | 0.09 | 0.08 | 0.05 | 0.06 |
| MgO | 3.33 | 2.09 | 1.14 | 0.71 | 0.39 |
| CaO | 6.79 | 3.62 | 2.68 | 1.84 | 1.14 |
| $\mathrm{Na}_{2} \mathrm{O}$ | 3.48 | 3.67 | 3.47 | 3.68 | 3.55 |
| $\mathrm{~K}_{2} \mathrm{O}$ | 2.45 | 3.00 | 4.00 | 4.07 | 4.30 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 0.21 | 0.25 | 0.19 | 0.12 | 0.07 |

## Series C

|  | C 1 | C 2 | C 3 | C 4 | C 5 |
| :--- | ---: | ---: | ---: | ---: | ---: |
| $\mathrm{SiO}_{2}$ | 49.20 | 50.14 | 50.14 | 50.18 | 50.44 |
| $\mathrm{TiO}_{2}$ | 1.84 | 1.49 | 1.12 | 1.14 | 1.00 |
| $\mathrm{Al}_{2} \mathrm{O}_{3}$ | 15.74 | 15.02 | 15.48 | 15.26 | 16.28 |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | 3.79 | 3.45 | 3.01 | 2.86 | 2.21 |
| FeO | 7.13 | 8.16 | 7.62 | 8.05 | 7.39 |
| MnO | 0.20 | 0.16 | 0.12 | 0.19 | 0.14 |
| MgO | 6.73 | 6.40 | 7.59 | 6.78 | 8.73 |
| CaO | 9.47 | 8.90 | 9.58 | 9.24 | 9.41 |
| $\mathrm{Na}_{2} \mathrm{O}$ | 2.91 | 2.91 | 2.39 | 2.56 | 2.26 |
| $\mathrm{~K}_{2} \mathrm{O}$ | 1.10 | 0.99 | 0.93 | 1.04 | 0.70 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 0.35 | 0.25 | 0.24 | 0.27 | 0.15 |

This work will be marked. Please return to me before Tuesday 14 February 2006, 9 am your answers to questions $\boldsymbol{A}-\boldsymbol{C}$ in part II.

