Lecture Notes - Petrology - Igneous Rock Names

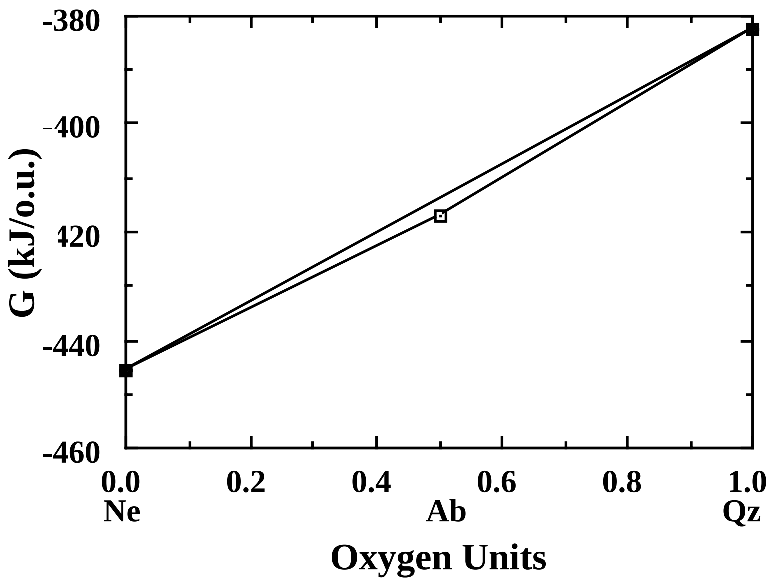
- Geologists have developed many classification schemes for igneous rocks. Most use **texture**, **mineralogy**, and **chemistry** (in that order) to determine a rock's name. The first cut is to separate coarse-grained (generally **plutonic**) from fine-grained (generally **volcanic**) rocks. We will follow this protocol and the recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks (see handout). Because many igneous rock names have associations with particular countries or particular geologists, an international committee was needed to settle on a common classification scheme!

- For plutonic rocks with less than 90% (by volume) **mafic** (dark) minerals, the rock name is determined from the relative proportions of quartz, alkali feldspars, plagioclase feldspars, and feldspathoids (see figure 1 of the handout). For **ultramafic** rocks (containing greater than 90% (by volume) mafic (dark) minerals), the relative proportions of olivine, orthopyroxene, clinopyroxene, and amphibole are used to determine the rock name. Classification schemes for other special rocks and recommendations for name modifiers are also given. A simplified field classification scheme is suggested for hand samples.

- Because the mineral composition of a volcanic rock depends more on the crystallization history than the mineral composition of a plutonic rock, agreeing upon names for volcanic rocks was more problematic. For example, two very different volcanic rocks may form from the same magma: one with few minerals and much glass and the other with many minerals and little glass. Should these two rocks be given the same name or different names? The Subcommission recommended that whenever possible, the name of a volcanic rock should be based on its modal mineralogy following a scheme analogous to the QAPF scheme used for plutonic rocks (see handout).

- The IUGS scheme for the naming of igneous rocks is based in part on the fact that igneous rocks do not have both quartz and feldspathoid in their mode. Why is it that quartz and nepheline, for example, do not occur in the same rock? What determines whether two minerals can occur together in equilibrium? The simple answer is that two minerals will not occur together if a third mineral with an intermediate chemical composition is stable. In the case of quartz (SiO_2) and nepheline ($NaAlSiO_4$), the mineral with the intermediate composition is albite ($NaAlSi_3O_8$).

- The longer answer is that the mineral assemblage with the lowest Gibbs energy will form at equilibrium. The Gibbs energy of a mixture of two minerals is given by a straight line connecting the Gibbs energies of the two minerals on a Gibbs energy-composition diagram. The Gibbs energies (per oxygen unit) of nepheline, albite, and quartz at 800 K are shown in the figure. It is apparent from the figure that for any mixture of quartz and nepheline, there is a feldspar-bearing assemblage (either Ab + Qz or Ne + Ab) that has a lower Gibbs energy.



Another way of putting this is that the ΔG for the reaction Ne + Qz = Ab is negative so that the reaction will procede spontaneously to the right. In oxygen units the reaction is

$$4\ NaAlSiO_4 + 4\ SiO_2 = 8\ NaAlSi_3O_8$$

and the Gibbs energy change is given by

$$\Delta G = -4\ (-445.5055)\ -4\ (-382.6435)\ + 8\ (-417.0889) = -24.115\ \ (kJ/8\ o.u.\ of\ Ab).$$