

# GY303 Igneous & Metamorphic Petrology

Rock Classification Systems



# Igneous Rock Classification Systems

- Mineral content and proportions (mineral modes)
- Rock geochemistry
- Texture
- Tectonic environment



# Subdivisions of Igneous Rocks

- Volcanic: form at or near the earth's surface
- Hypabyssal: intrude at a depth less than 1 km
- Plutonic: intrude at a depth greater or equal to 1 km
- Extrusive: lava flows or ash flows/falls that are deposited on the surface
- Intrusive: intrude the lithosphere without penetrating to the earth's surface



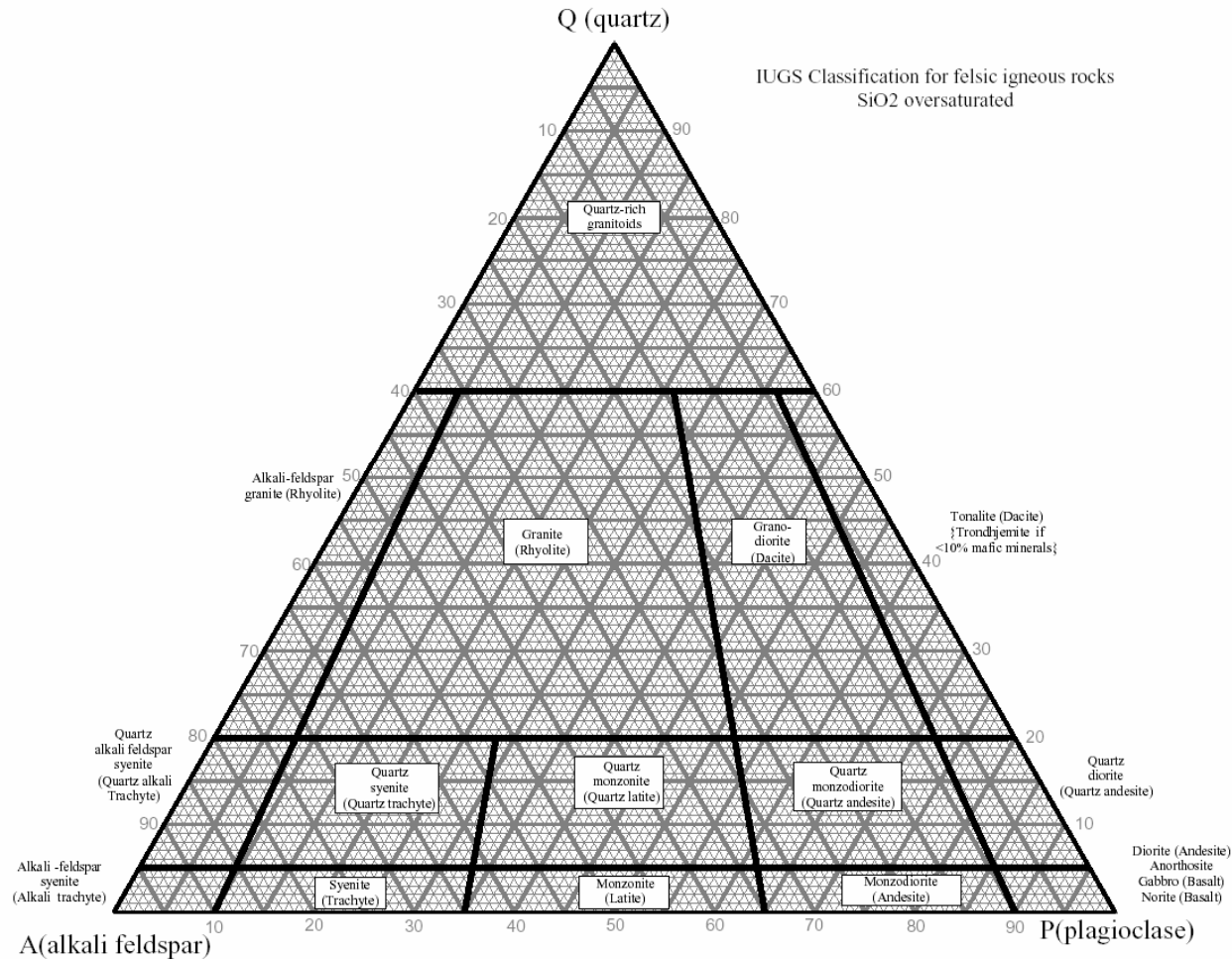
# Mineralogical Classifications

- Percent and type of feldspar
- Presence or absence of quartz, feldspathoids or olivine
- Percentage and type of ferromagnesian minerals (i.e. felsic, mafic, etc.)
- Grain size and texture of rock (aphanitic, phaneritic, porphyritic, etc.)



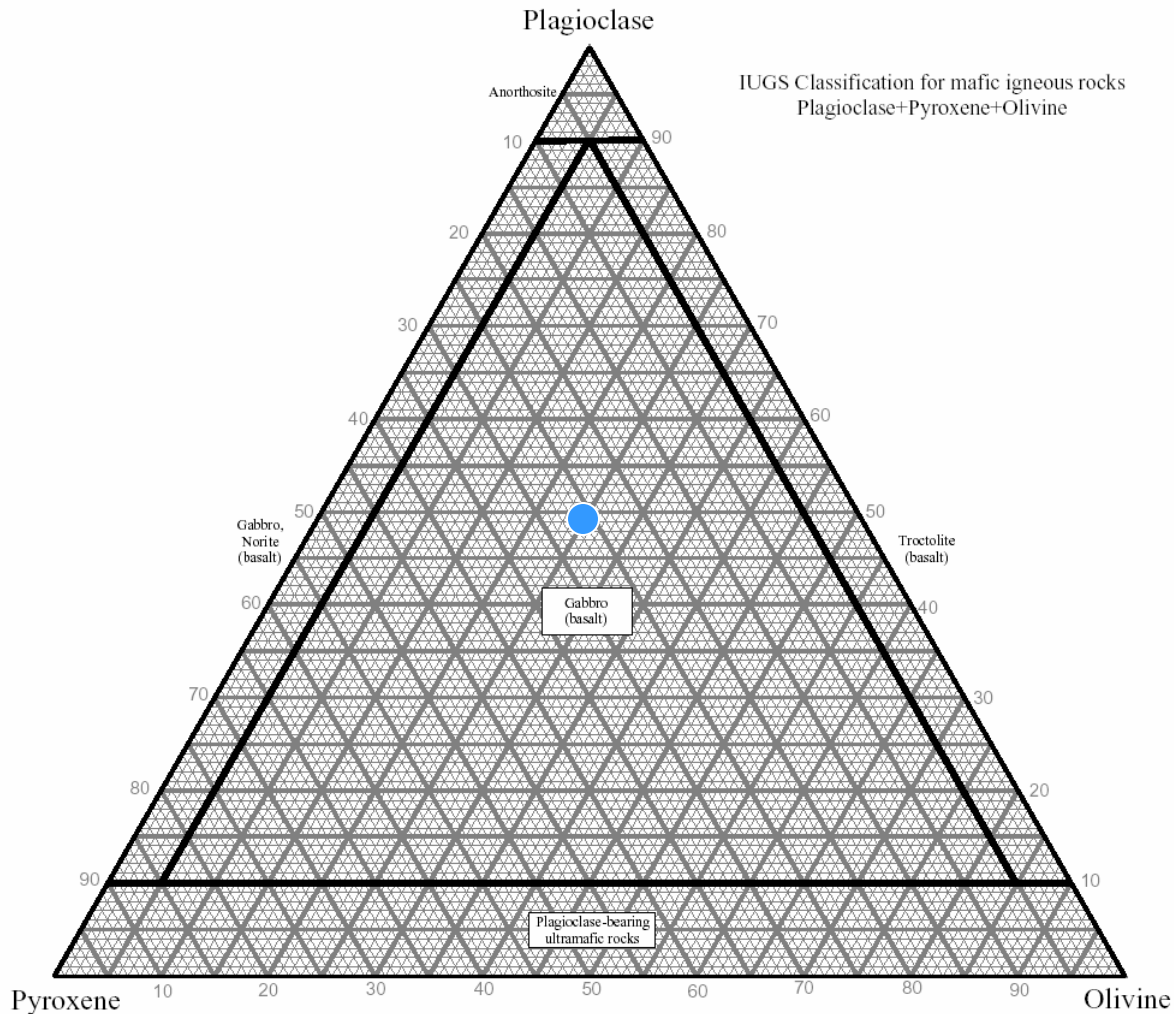
# Mineralogical Classification

## Diagrams: Felsic



- IUGS Felsic Ternary diagram with 3 most common minerals at apices
- Accessory minerals  $\geq 10\%$  modify the base name
- Extrusive equivalents in parentheses

# Mineralogical Classification Diagrams: Mafic



- Minerals modes must be recalculated to ternary percentages

Mode

40% Pl, 20% Pyx,  
20%

OI, 10% Mt, 10%  
Sphe

$$P = 40/80 \times 100 = 50\%$$

$$Pyx = 20/80 \times 100 = 25\%$$

$$OI = 20/80 \times 100 = 25\%$$

# Special Compositional & Textural Terms

- Diabase: hypabyssal mafic rock usually occurring in dikes and/or sills
- Trondhjemite: felsic igneous rock that is dominantly Na-plagioclase
- Plagiogranite: includes trondhjemite and quartz diorite
- Plagisyenite: equivalent to IUGS monzosyenite
- Quartz Monzonite: falls within the IUGS granite field. Used by North American geologists
- Keratophyre: Na trachyte in which albite or oligoclase dominate; associated with sea water alteration
- Spillite: basalt altered by sea water such that the Ca-plagioclase is replaced by Na-plagioclase
  - i.e.  $\text{Na}^+ + \text{Si}^{+4} \text{CaAl}_2\text{Si}_2\text{O}_8 = \text{Ca}^{2+} + \text{Al}^{3+} + \text{NaAlSi}_3\text{O}_8$



# Special Compositional and Textural Terms Continued

- Lamprophyre: dark-colored (melanocratic) dike rock containing euhedral mafic phenocrysts (Ol  $\pm$  Pyx  $\pm$  Bi  $\pm$  Hbl)
- Serpentinite: altered ultramafic rock found where sea water has reacted with mantle peridotite (producing actinolite  $\pm$  tremolite)
- Komatiite: ultramafic lava flow, usually Precambrian in age and contains spinifex texture
- Carbonatite: carbonate magma believed to be generated in the mantle wedge above subduction zones; Kimberlites are a special type
- Pegmatite: a very coarse grained granite; generated by hydrothermal systems
- Aplite: a Q + Alkali Feldspar rock that has a equigranular texture with anhedral grains
- Obsidian: volcanic glass, felsic in composition
- Porphyry: contains > 50% phenocrysts by volume



# Special Compositional & Textural Terms continued

- Pumice: frothy volcanic glass, usually has density less than water
- Scoria: extrusive volcanic rock that is composed of  $> 50\%$  vesicles (void space)
- Tuff: fine grained, fragmented volcanic rock that results from the eruption of viscous magma; usually the major component of ash flows and ash falls
- Volcanic breccia: large angular fragments surrounded by an ash matrix that is produced during the explosive eruption of a volcano



# Chemical Classifications of Igneous Rocks

- $\text{SiO}_2$  (silica) percentage by weight
- Note that  $\text{SiO}_2$  is considered here as a chemical component- not the mineral phase quartz

<u>%<math>\text{SiO}_2</math></u>	<u>Designation</u>
>66%	Felsic
66-52%	Intermediate
52-45%	Mafic
<45%	Ultramafic



# Chemical Classification of Igneous Rocks cont.

- C.I.P.W Normative mineralogy: a theoretical mineralogy calculated from a weight % oxides chemical analysis
- Derived from publication in 1906 by Cross, Iddings, Pierce and Washington (USGS)
- Intended to allow comparison of fine-grained extrusive rock to intrusive igneous rocks.
- Assumes that the magma is “dry”, and that the  $\text{Fe}^{2+}/\text{Fe}^{3+}$  is the same in all ferromagnesian minerals



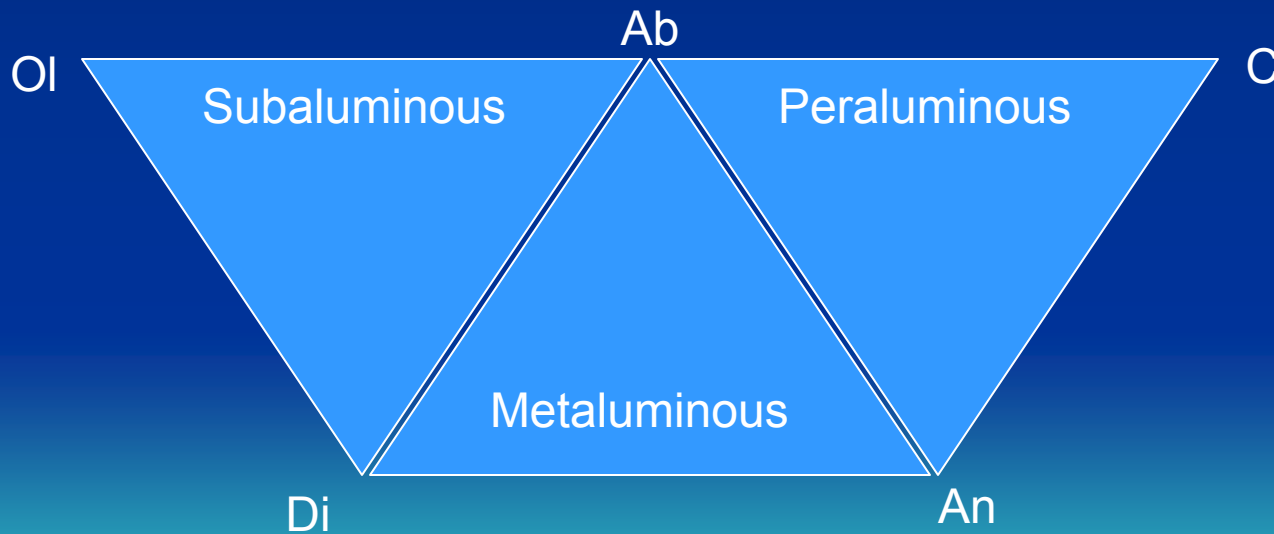
# Limitations of Normative Mineralogy Calculations

- Does not calculate hydrous mineral phases that may be a significant proportion of actual rock (i.e. mica, amphibole, epidote, etc.)
- Assumes a constant Fe/Mg ratio, for all minerals
- Assumes a Fe<sup>2+</sup>/Fe<sup>3+</sup> ratio because analytical instruments typically do not detect differences in Fe oxidation state



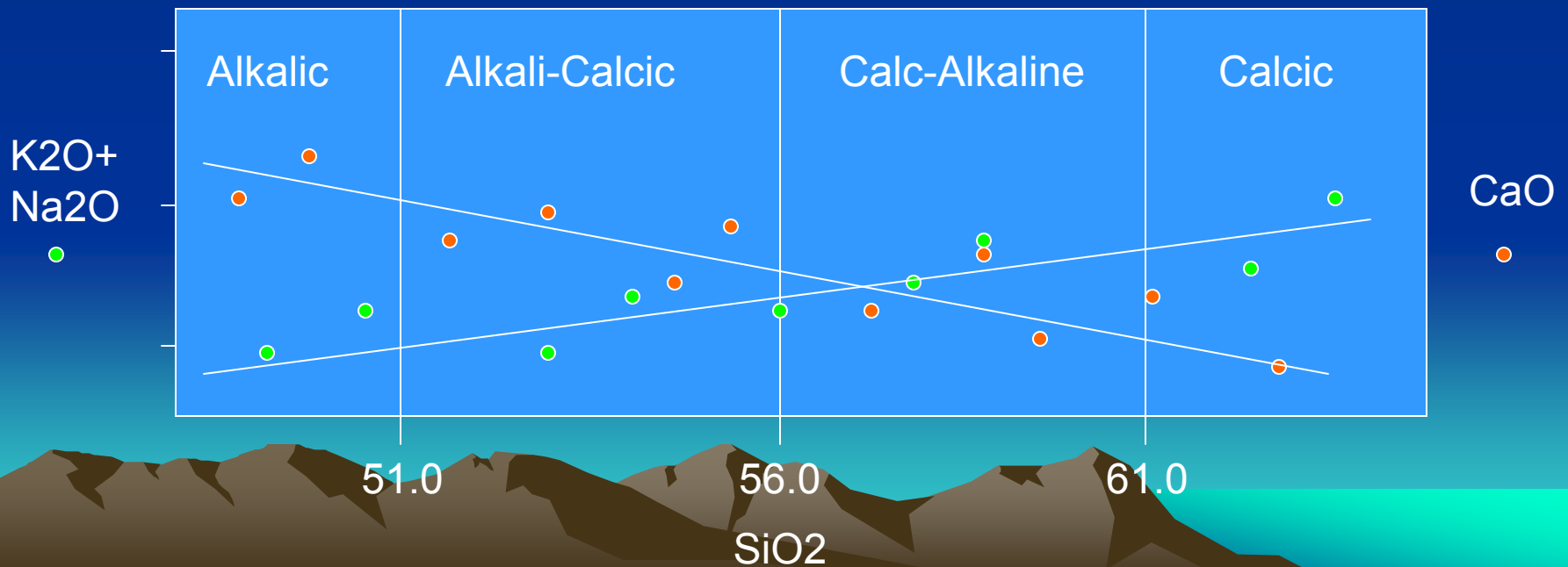
# Aluminum Saturation

- Classification is indexed to the degree of  $Al_2O_3$  abundance as indicated by normative mineralogy



# Alkali-Lime Index

- Weight percent oxide plot of  $\text{SiO}_2$  versus  $\text{Na}_2\text{O}+\text{K}_2\text{O}$  (Alkalis) on one y axis, and  $\text{CaO}$  (Lime) on another y axis



# Igneous Rock Associations: Mafic & Ultramafic

- Mafic & Ultramafic Associations
  - Ophiolites: peridotite, serpentinite, gabbro, diabase dikes, pillow basalt, spillite
  - Continental Rift: Flood alkali basalts, basalt-rhyolite flows (bimodal volcanics), syenite, diabase dikes
  - Precambrian shield: Gabbroic layered intrusions (lopoliths), anorthosite



# Igneous Rock Associations: Intermediate & Felsic

- Volcanic Arc: andesite – dacite – rhyolite sequences from trench to arc (i.e.  $> \text{SiO}_2$  content with distance from trench) (Calc-Alkaline series)
- High viscosity magma: pyroclastic eruptive style
- Batholithic magmatic arc: diorite – granodiorite – monzonite – granite sequence with distance from trench (Calc-Alkaline series)
- Base of overriding plate: anorthosites



# Igneous Rock Associations: Alkaline Igneous Rocks

- Continental Rift: Syenite – Nepheline  
Syenite – Carbonatite intrusives; alkali  
basalt; trachyte – phonolite volcanics;  
diabase dikes
- Continental Hot Spots: Trachyte –  
Phonolite volcanics; Alkali basalt flood  
basalts
- Oceanic Hot Spots: Alkali basalt

