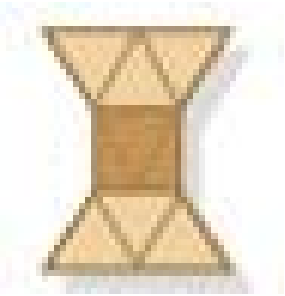
12.109 Lecture Notes
September 15, 2005

Rock Forming Minerals III
Structure and composition of: PYROXENES

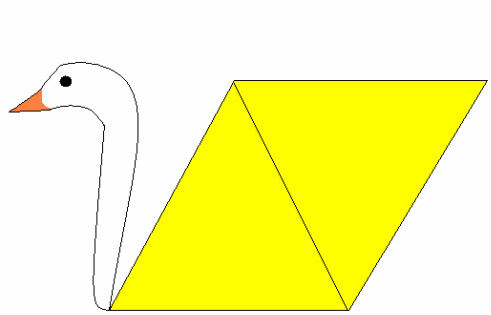
Pyroxenes = chain silicates, with tetrahedral and octahedral chains

Pyroxene structure combines tetrahedral chains + octahedral strip → I-beams



Diopside CaMgSi2O6
Monoclinic, due to symmetry of octahedra

"Octahedral ducks"



The symmetry of a pyroxene can depend on the facing direction of the octahedra. To remember this, we picture the octahedron as a duck, and signify as positive "ducks facing forwards" and as negative "ducks facing backwards."

<u>How to make an orthorhombic pyroxene</u>

Pyroxene structure is a polytype
Polytypism – one basic building unit put together in different ways

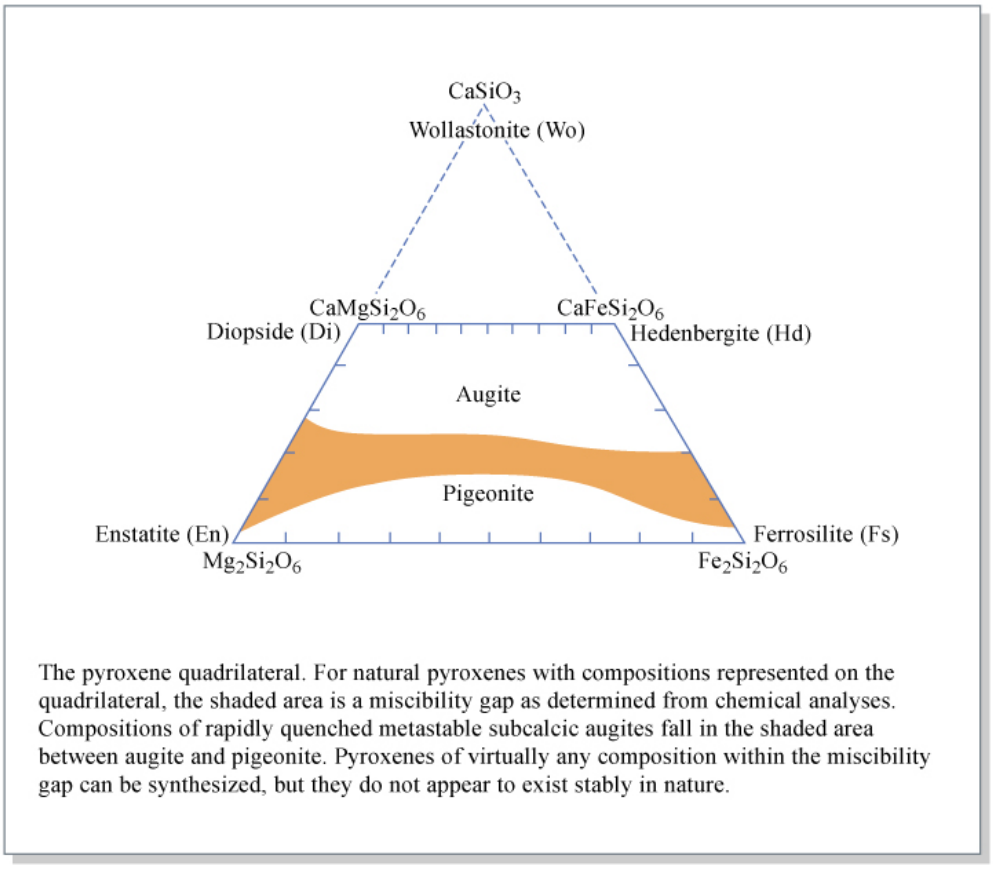
Orthopyroxene (OPX)
Stack I-beams in rows alternating directionality of octahedrons

Pyroxene polytypes

+ monoclinic c·2/c
+ CPX
+ clinopyroxene, diopside
+
+

+
- orthorhombic Pbcn
+ protoenstatite
-
+
+ orthorhombic Pbcn
+ OPX
- orthopyroxene
-
+
+

Pyroxene quadrilateral



The pyroxene quadrilateral. For natural pyroxenes with compositions represented on the quadrilateral, the shaded area is a miscibility gap as determined from chemical analyses. Compositions of rapidly quenched metastable subcalcic augites fall in the shaded area between augite and pigeonite. Pyroxenes of virtually any composition within the miscibility gap can be synthesized, but they do not appear to exist stably in nature.

Other types of pyroxenes
$NaAlSi_2O_6$ jadeite
$NaFeSi_2O_6$ aegirine
$LiAlSi_2O_6$ spodumene

$CaAl(Al, Si)O6$ CaTs Calcium Tschermaks
Fassaite = >50% CaTs
$MgAl(Al, Si)O6$ MgTs Magnesium Tschermaks

Augites can have substantial amounts of Ti in M1 site → Ti-CaTs ($R^{2+}TiAl_2O_6$, where R can be any of a number of 2+ elements)
Or with Cr, Cr-CaTs, distinctive green pyroxenes ($R^{2+}CrAlSiO_6$)

Protoenstatite almost pure Mg pyroxene, like enstatite
found in meteorites, enstatite chondrites
boninites – discovered 1989, contain protoenstatite
produced in subduction zones

<u>compositional variation in pyroxenes due to temperature</u>
when you look at pyroxenes in thin section, commonly you see evidence for exsolution – unmixing of components, chemical separation
important in petrology because provides a record of temperature history

In thin section, see blebs of unmixed mineral, esp. in plutonic rocks (slowly cooled igneous intrusives) or in high T igneous rocks where minerals grow directly from melt
Can tell about rate of cooling

@ low T, pigeonite phase disappears, reacts to form OPX and augite
In plutonic rocks, get inverted pigeonite, OPX with augite lamelli
Pigeonite → augite + OPX makes martensite, similar to phase transition in carbon-iron system