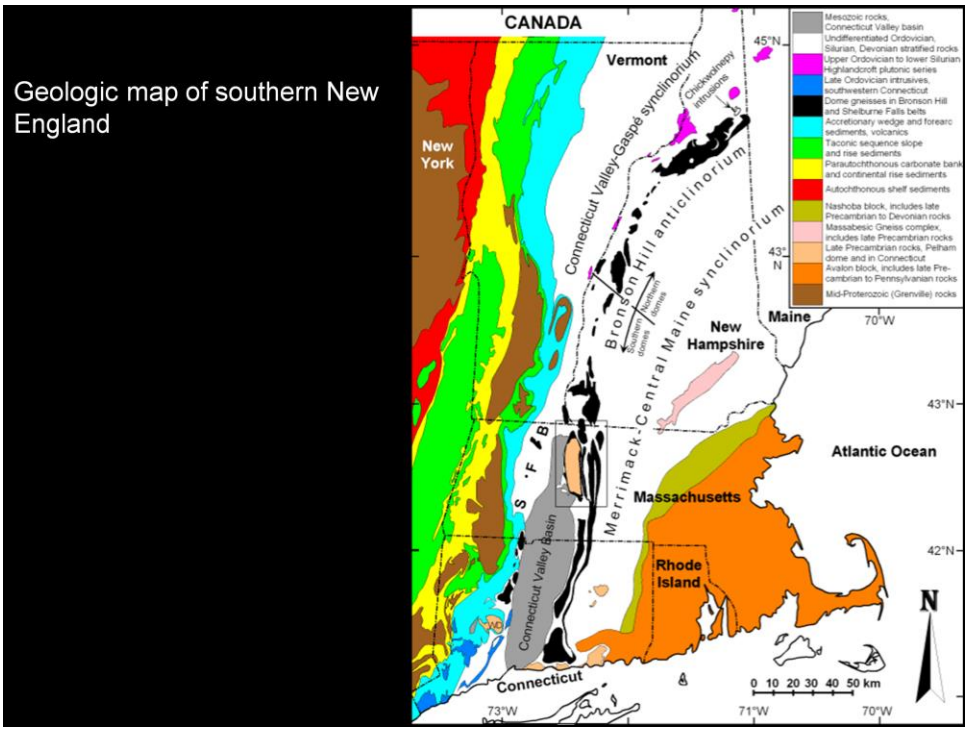
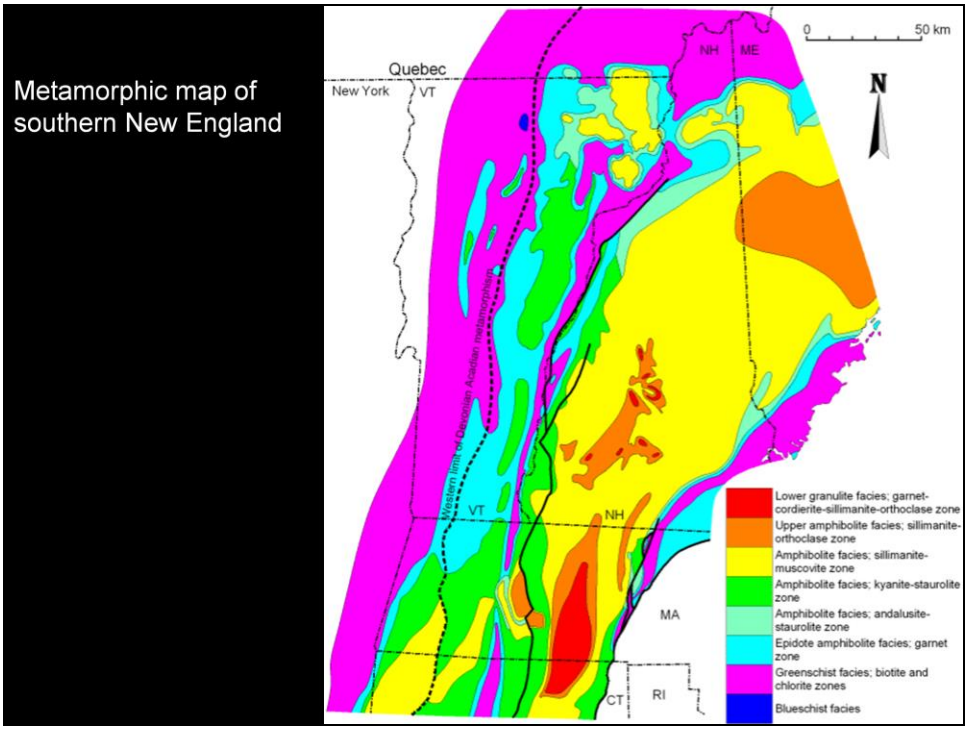


All of the samples collected here are from the white rocks in the Connecticut Valley-Gaspé synclinorium, Bronson Hill anticlinorium, and Merrimack-Central Maine synclinorium.

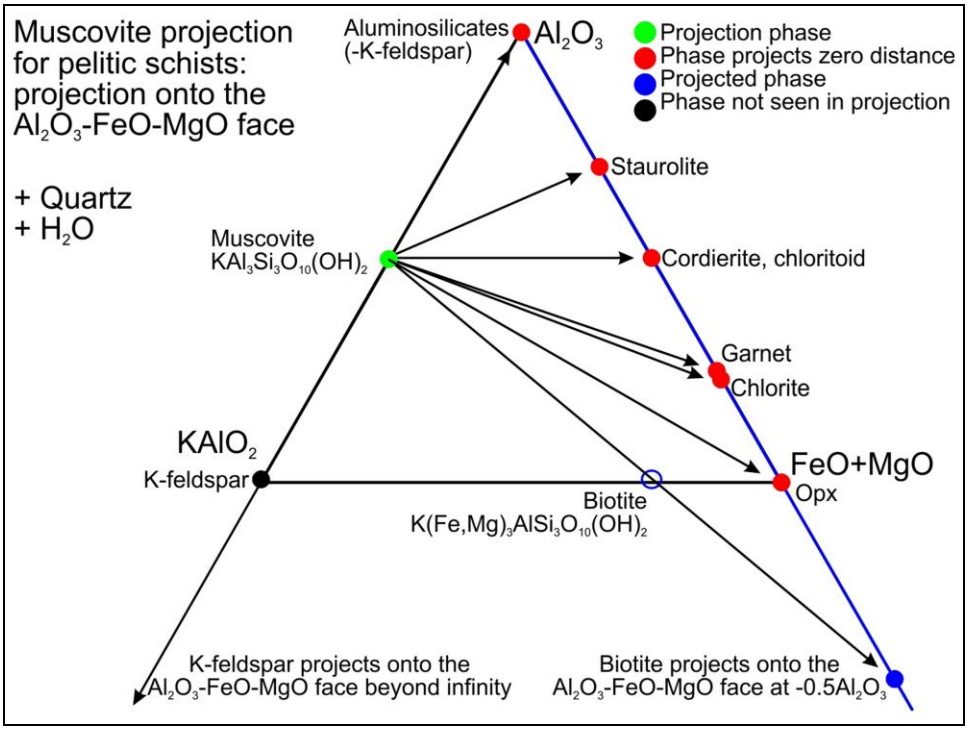


The samples were all metamorphosed in the Acadian (Devonian), though some in the south experienced high-grade metamorphism continuing into the Pennsylvanian. Pressures of metamorphism ranged from about 4 to 6 kbars.

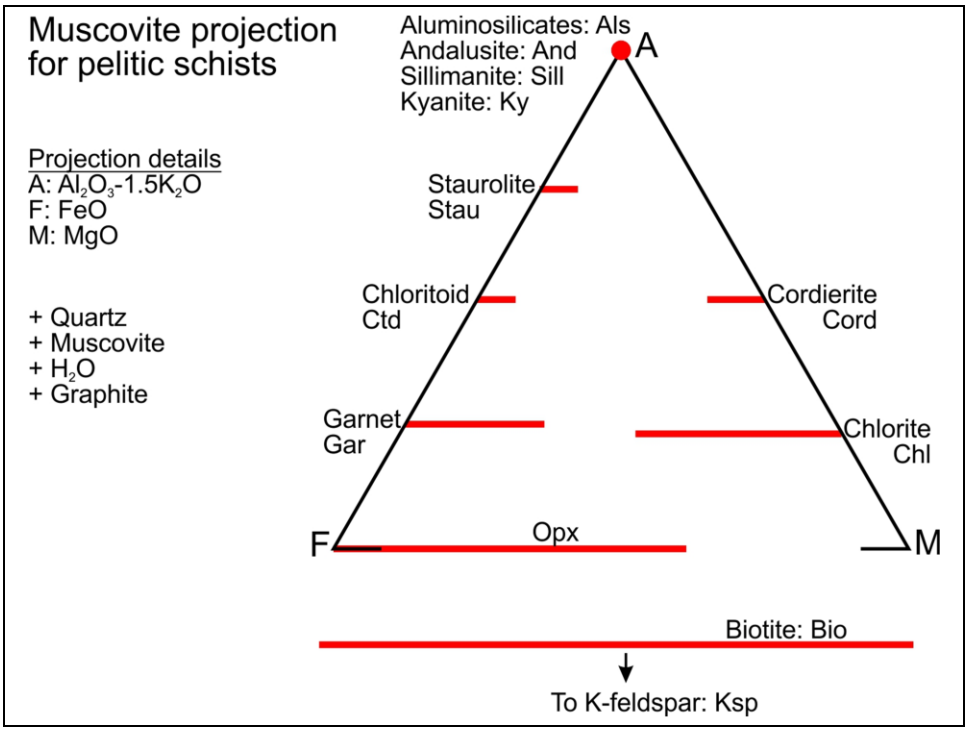
	Basalt	Shale	
SiO_2	50.41	65.40	Shale more
TiO_2	1.22	0.84	Shale less
Al_2O_3	15.93	16.50	
FeO	8.83	6.63	
MnO	0.16	0.12	
MgO	8.55	2.72	
CaO	11.82	2.44	
Na_2O	2.56	1.41	
K_2O	0.16	3.50	
P_2O_5	0.14	0.18	
S	0.21	0.26	
Total	100.00	100.00	

Basalt data from Kelemen et al. (2004) and Oppenheimer (2004), shale data from Li (1991).

Basaltic and pelitic (shale) rocks differ in composition principally with the shales being richer in silica, potassium, and (slightly) aluminum, and poorer in Mg, Ca, and Na. Having less Ca and slightly more Al makes non-calcareous shales strongly peraluminous, with considerably more Al than is needed to make feldspars. This leaves a lot of Al left over to make aluminous minerals like muscovite, garnet, staurolite, cordierite, and Al-silicates.

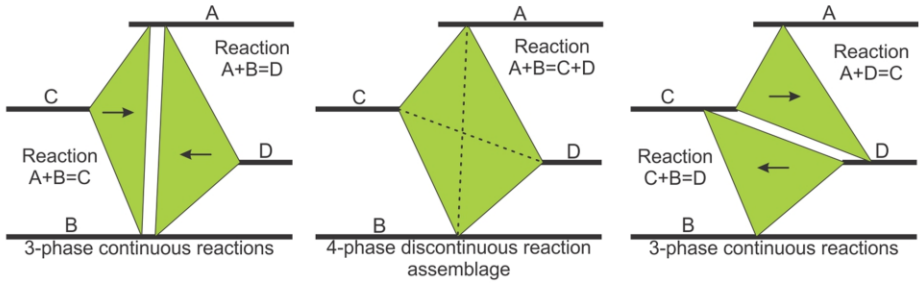


AFM projected face



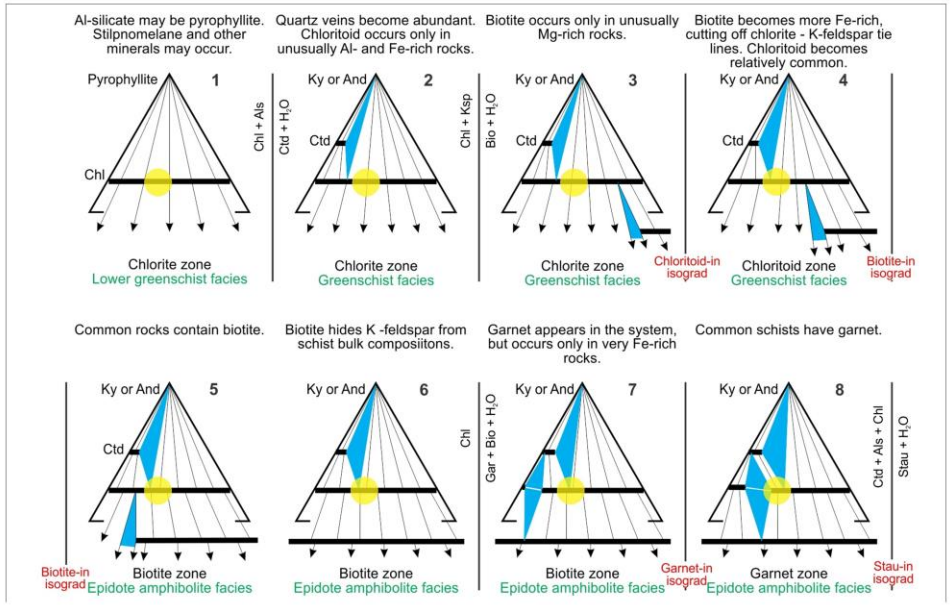
Projection from muscovite

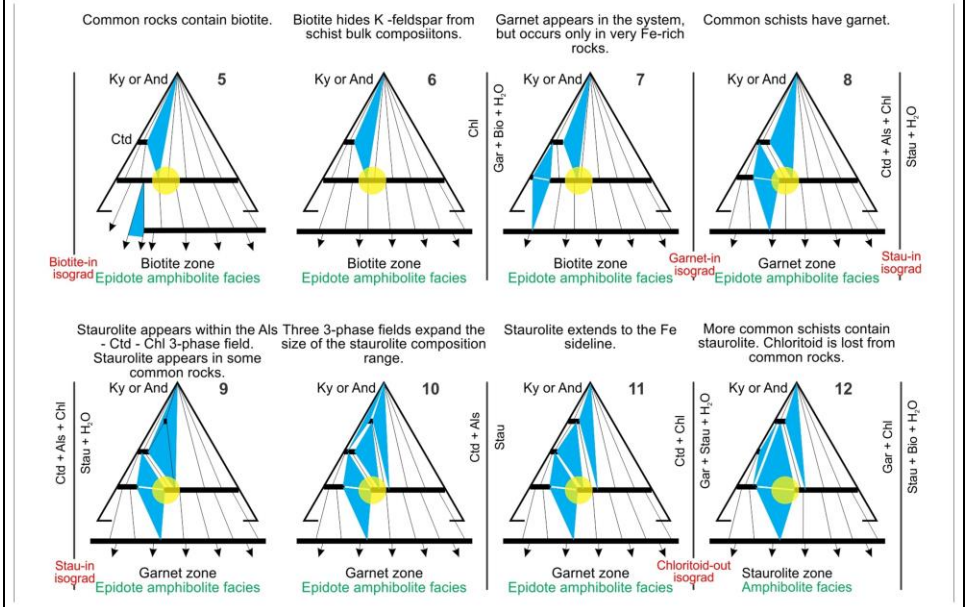
Example 3- and 4-phase reactions that result in switching A-B for C-D tie lines

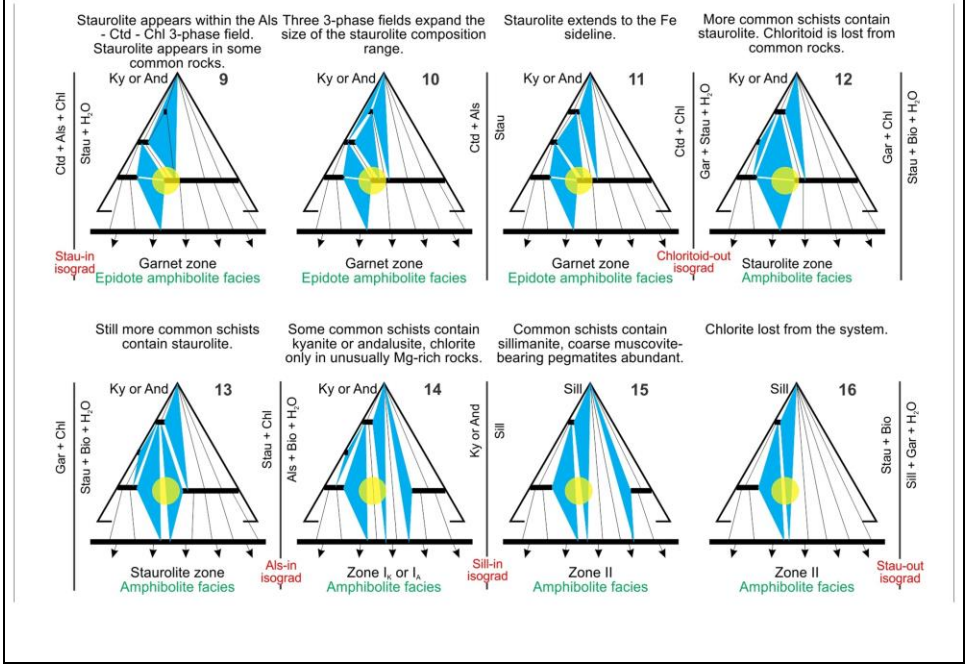


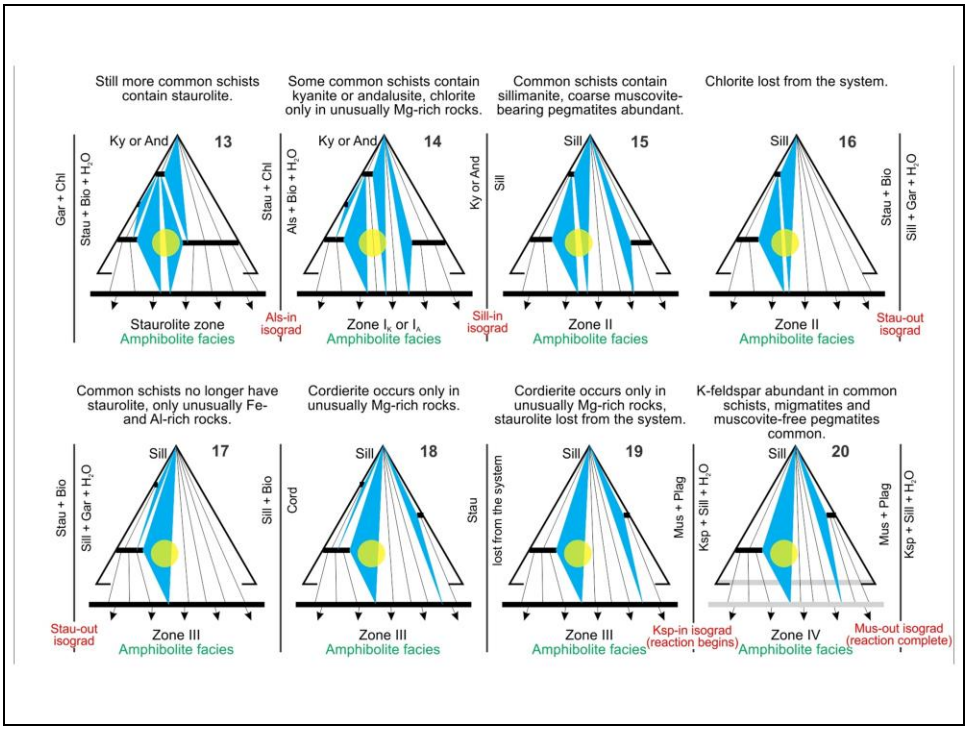
Abbreviations for the following diagrams:

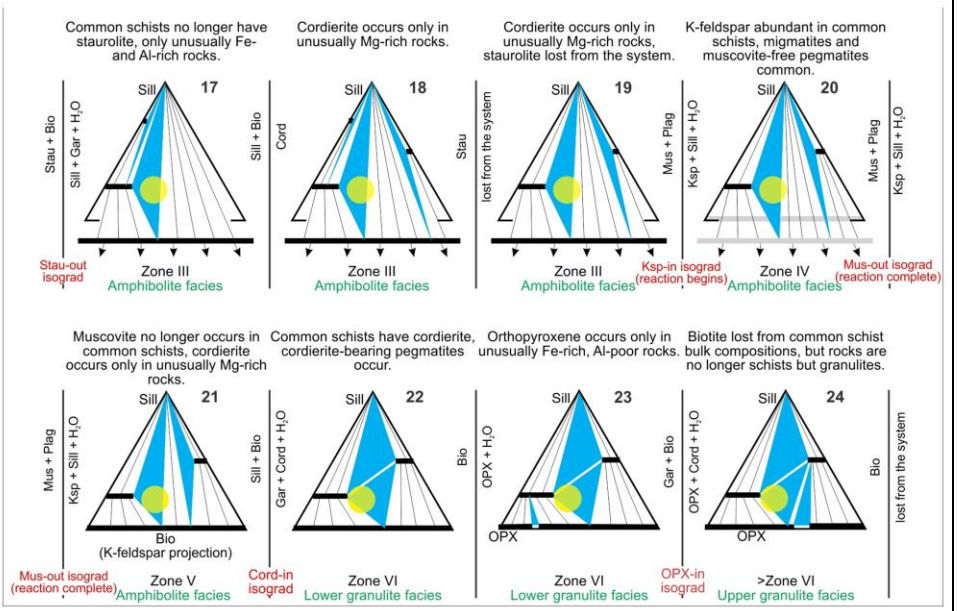
Chl=Chlorite, Ky=Kyanite, And=Andalusite, Sill=Sillimanite, Als=Aluminosilicate (Ky, And, Sill), Ctd=Chloritoid, Ksp=K-feldspar, Bio=Biotite, Stau=Staurolite, Gar=Garnet, Cord=Cordierite, Mus=Muscovite, Plag=Plagioclase, Opx=Orthopyroxene


Al-silicate may be pyrophyllite. Stilpnomelane and other minerals may occur.
Quartz veins become abundant. Chloritoid occurs only in unusually Al- and Fe-rich rocks.
Biotite occurs only in unusually Mg-rich rocks.
Biotite becomes more Fe-rich, cutting off chlorite - K-feldspar tie lines. Chloritoid becomes relatively common.
Pyrophyllite
1
Chl
Chl + Als
Ky or And
2
Ctd
Ctd + H2O
Chl + Ksp
Ky or And
3
Ctd
Bio + H2O
Ky or And
4
Ctd
Chlorite zone
Lower greenschist facies
Chlorite zone
Greenschist facies
Chlorite zone
Greenschist facies
Chloritoid-in isograd
Chloritoid zone
Greenschist facies
Biotite-in isograd
Common rocks contain biotite.
Biotite hides K -feldspar from schist bulk composiitons.
Garnet appears in the system, but occurs only in very Fe-rich rocks.
Common schists have garnet.
Ky or And
5
Ctd
Ky or And
6
Chl
Gar + Bio + H2O
Ky or And
7
Ky or And
8
Ctd + Als + Chl
Stau + H2O
Biotite-in isograd
Biotite zone
Epidote amphibolite facies
Biotite zone
Epidote amphibolite facies
Biotite zone
Epidote amphibolite facies
Garnet-in isograd
Garnet zone
Epidote amphibolite facies
Stau-in isograd


Common rocks contain biotite.
Biotite hides K -feldspar from schist bulk composiitons.
Garnet appears in the system, but occurs only in very Fe-rich rocks.
Common schists have garnet.
Ky or And
5
Ctd
Biotite-in isograd
Biotite zone
Epidote amphibolite facies
Ky or And
6
Chl
Biotite zone
Epidote amphibolite facies
Ky or And
7
Gar + Bio + H2O
Biotite zone
Epidote amphibolite facies
Garnet-in isograd
Ky or And
8
Ctd + Als + Chl
Stau + H2O
Garnet zone
Epidote amphibolite facies
Stau-in isograd
Staurolite appears within the Als - Ctd - Chl 3-phase field. Staurolite appears in some common rocks.
Three 3-phase fields expand the size of the staurolite composition range.
Staurolite extends to the Fe sideline.
More common schists contain staurolite. Chloritoid is lost from common rocks.
Ky or And
9
Ctd + Als + Chl
Stau + H2O
Stau-in isograd
Garnet zone
Epidote amphibolite facies
Ky or And
10
Ctd + Als
Garnet zone
Epidote amphibolite facies
Ky or And
11
Stau
Ctd + Chl
Garnet zone
Epidote amphibolite facies
Chloritoid-out isograd
Ky or And
12
Gar + Stau + H2O
Gar + Chl
Stau + Bio + H2O
Staurolite zone
Amphibolite facies


Staurolite appears within the Als - Ctd - Chl 3-phase field. Staurolite appears in some common rocks.
Three 3-phase fields expand the size of the staurolite composition range.
Staurolite extends to the Fe sideline.
More common schists contain staurolite. Chloritoid is lost from common rocks.
Ky or And
9
10
11
12
Ctd + Als + Chl
Stau + H2O
Ctd + Als
Stau
Ctd + Chl
Gar + Stau + H2O
Gar + Chl
Stau + Bio + H2O
Stau-in isograd
Garnet zone
Epidote amphibolite facies
Chloritoid-out isograd
Staurolite zone
Amphibolite facies
Still more common schists contain staurolite.
Some common schists contain kyanite or andalusite, chlorite only in unusually Mg-rich rocks.
Common schists contain sillimanite, coarse muscovite-bearing pegmatites abundant.
Chlorite lost from the system.
13
14
Sill
15
16
Gar + Chl
Stau + Bio + H2O
Stau + Chl
Als + Bio + H2O
Ky or And
Sill
Stau + Bio
Sill + Gar + H2O
Staurolite zone
Amphibolite facies
Als-in isograd
Zone IK or IA
Sill-in isograd
Zone II
Stau-out isograd


Still more common schists contain staurolite.
Some common schists contain kyanite or andalusite, chlorite only in unusually Mg-rich rocks.
Common schists contain sillimanite, coarse muscovite-bearing pegmatites abundant.
Chlorite lost from the system.
Ky or And
13
Gar + Chl
Stau + Bio + H2O
Staurolite zone
Amphibolite facies
Als-in isograd
Ky or And
14
Stau + Chl
Als + Bio + H2O
Zone IK or IA
Amphibolite facies
Sill-in isograd
Sill
15
Ky or And
Zone II
Amphibolite facies
Sill
16
Stau + Bio
Sill + Gar + H2O
Zone II
Amphibolite facies
Stau-out isograd
Common schists no longer have staurolite, only unusually Fe- and Al-rich rocks.
Cordierite occurs only in unusually Mg-rich rocks.
Cordierite occurs only in unusually Mg-rich rocks, staurolite lost from the system.
K-feldspar abundant in common schists, migmatites and muscovite-free pegmatites common.
Sill
17
Stau + Bio
Sill + Gar + H2O
Zone III
Amphibolite facies
Stau-out isograd
Sill
18
Sill + Bio
Cord
Zone III
Amphibolite facies
Sill
19
Stau
lost from the system
Zone III
Amphibolite facies
Ksp-in isograd (reaction begins)
Sill
20
Mus + Plag
Ksp + Sill + H2O
Zone IV
Amphibolite facies
Mus + Plag
Ksp + Sill + H2O
Mus-out isograd (reaction complete)


Common schists no longer have staurolite, only unusually Fe- and Al-rich rocks.
Sill
17
Stau + Bio
Sill + Gar + H2O
Sill + Bio
Stau-out isograd
Zone III
Amphibolite facies
Cordierite occurs only in unusually Mg-rich rocks.
Sill
18
Cord
Stau
Zone III
Amphibolite facies
Cordierite occurs only in unusually Mg-rich rocks, staurolite lost from the system.
Sill
19
lost from the system
Mus + Plag
Ksp + Sill + H2O
Zone III
Amphibolite facies
Ksp-in isograd (reaction begins)
K-feldspar abundant in common schists, migmatites and muscovite-free pegmatites common.
Sill
20
Mus + Plag
Ksp + Sill + H2O
Zone IV
Amphibolite facies
Mus-out isograd (reaction complete)
Muscovite no longer occurs in common schists, cordierite occurs only in unusually Mg-rich rocks.
Sill
21
Mus + Plag
Ksp + Sill + H2O
Sill + Bio
Bio
(K-feldspar projection)
Mus-out isograd (reaction complete)
Zone V
Amphibolite facies
Common schists have cordierite, cordierite-bearing pegmatites occur.
Sill
22
Gar + Cord + H2O
Bio
Cord-in isograd
Zone VI
Lower granulite facies
Orthopyroxene occurs only in unusually Fe-rich, Al-poor rocks.
Sill
23
OPX + H2O
Gar + Bio
OPX
Zone VI
Lower granulite facies
OPX-in isograd
Biotite lost from common schist bulk compositions, but rocks are no longer schists but granulites.
Sill
24
OPX + Cord + H2O
Bio
lost from the system
OPX
>Zone VI
Upper granulite facies