METAMORPHIC FACIES & MINERAL VARIATIONS

PAPER- METAMORPHIC PETROLOGY

PAPER CODE- MGELCC-7,SEMESTER-2ND

Prepared By:

Dr. K. BIJENDRA PRATAP RAHI.

GUEST ASSISTANT PROFESSOR, DEPARTMENT OF GEOLOGY, PATNA UNIVERSITY, PATNA

E mail ID- bijendrapratap007@gmail.com
Mobile No- 8789608216

METAMORPHIC FACIES:

Metamorphic rocks are often classified on the basis of metamorphic facies. Parent rocks of different compositions, if metamorphosed under the same pressure-temperature conditions, will characteristically contain the same set of definite minerals. They are said to belong to the same metamorphic facies. A "metamorphic facies" therefore, may be defined as a group of metamorphic rocks that have formed under the same set of phsico-chemical conditions and is characterized by a definite set of minerals.

P. Eskola (1915), classified and grouped systematically the diverse type of metamorphic rocks on the basis of:

a. Diagnostic mineral assemblages.

b. Mineralogical & chemical composition.

c. Pressure-temperature conditions.

Eskola (1920) proposed 5 original facies:

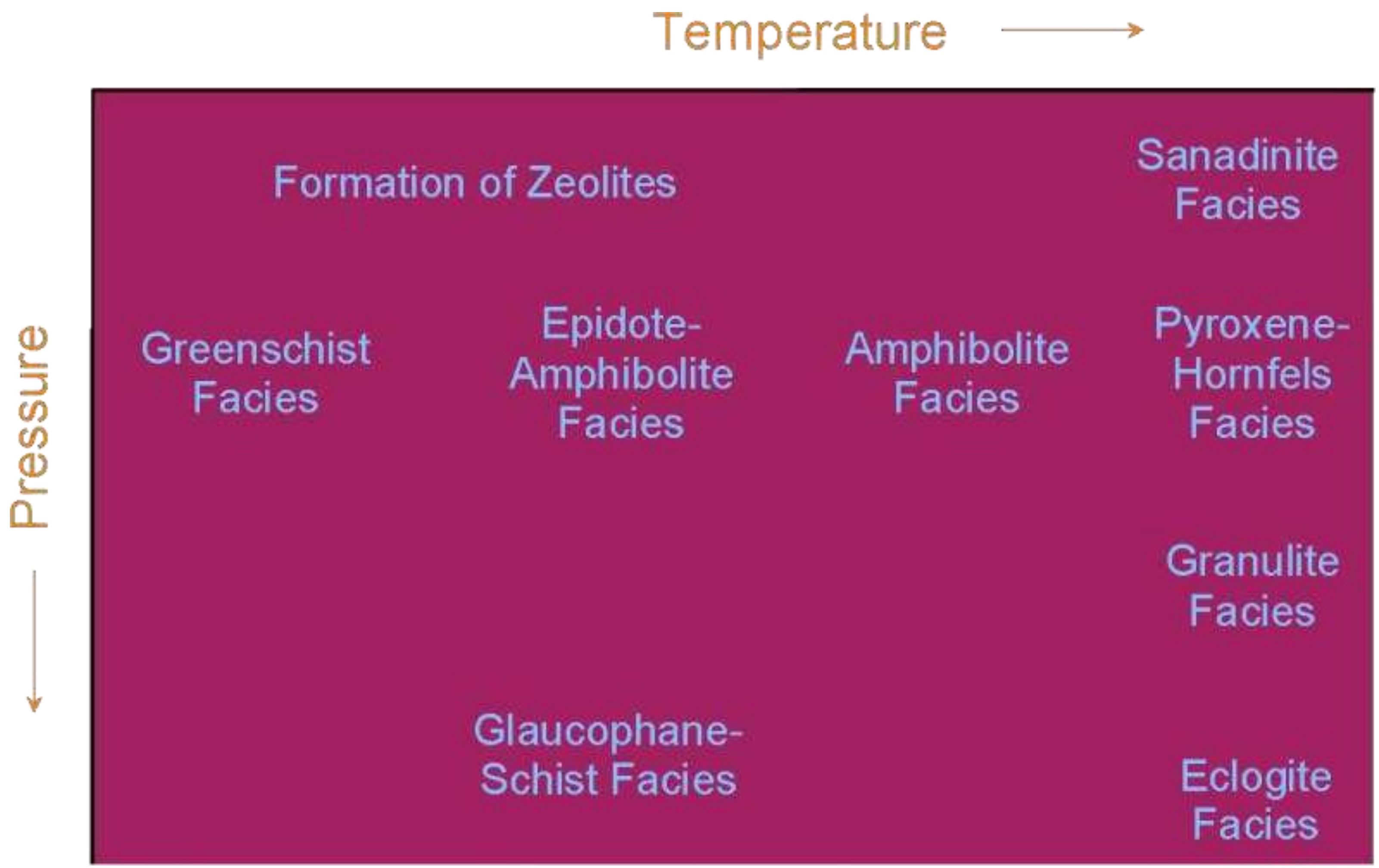
- Greenschist
- Amphibolite
- Hornfels
- Sanidinite
- Eclogite

Easily defined on the basis of mineral assemblages that develop in mafic rocks, which are abundant in most terranes and mineral changes define a broad range of P & T

In his final account, Eskola (1939) added:

- Granulite
- Epidote-amphibolite
- Glaucophane-schist (now called Blueschist)

... and changed the name of the hornfels facies to the pyroxene hornfels facies



Winter (2001) Fig. 25-1 The metamorphic facies proposed by Eskola and their relative temperature-pressure relationships. After Eskola (1939) *Die Entstehung der Gesteine*. Julius Springer. Berlin

The concept of metamorphic facies series was given by A. Miyashiro in 1960.

1. (Low pressure series)- Andalusite- Sillimanite facies: Abukama type, Japan.
   Zeolite Facies: This facies represents the lowest grade of metamorphism. Coombs (Newzealand) discovered Zeolite facies in 1954. The mineral assemblages include zeolites, chlorite, muscovite and quartz.
2. (Medium pressure facies series): Kyanite- Sillimanite series.
   a. Green schist Facies: This facies represents low grade of metamorphism found in many regionally metamorphosed areas. Abundance of green minerals present in this facies gives the name to this facies. The mineral assemblages of green-schist facies include chlorite, chloritoid, epidote, actinolite, muscovite, albite (anorthite< 7%) and quartz.
      Muscovite (Si:Al> 3:1)
   b. Amphibolite Facies: This facies is found in medium to high grade metamorphic terrains. Amphibolite facies represents, metamorphic

conditions which occure in staurolite & sillimanite grade of metamorphism. The mineral assemblages includes hornblende, plagioclase and almandite.

c. Glaucophane Lawsonite Schist Facies: This facies is also known as Blue-schist facies. This facies represents the metamorphism that takes place in conditions of relatively low temperature but high pressure. Such conditions commonly occur in young orogenic zones, such as California (U.S.A.) and Japan. Glaucophane is the characteristic mineral. The mineral assemblages include lawsonite, albite, jadeite, glaucophane (blue in colour), muscovite & garnet.

d. Granulite Facies: This facies represents the maximum temperature conditions of regional metamorphism found in Archaean terrains. The characteristic minerals of this facies are plagioclase, hypersthenes, garnet & diopside.

e. Eclogite Facies:

This facies represents the most deep seated conditions of metamorphism. Such mineral assemblages are commonly found in kimberlite pipes, many of which contain diamonds. The characterstic minerals are pyrope garnet and omphacite.

Table 25-1. Definitive Mineral Assemblages of Metamorphic Facies

Facies	Definitive Mineral Assemblage in Mafic Rocks
Zeolite	zeolites: especially laumontite, wairakite, analcime
Prehnite-Pumpellyite	prehnite + pumpellyite (+ chlorite + albite)
Greenschist	chlorite + albite + epidote (or zoisite) + quartz ± actinolite
Amphibolite	hornblende + plagioclase (oligoclase-andesine) ± garnet
Granulite	orthopyroxene (+ clinopyrixene + plagioclase ± garnet ± hornblende)
Blueschist	glaucophane + lawsonite or epidote (+albite ± chlorite)
Eclogite	pyrope garnet + omphacitic pyroxene (± kyanite)
Contact Facies	Mineral assemblages in mafic rocks of the facies of contact meta-morphism do not differ substantially from that of the corresponding regional facies at higher pressure.

After Spear (1993)

Lower Temperature Limit Mineral Variations:

Analcime ($NaAlSi_2O_6.H_2O$)+ Quartz (SiO_2)= Albite ($NaAlSi_3O_8$)+ H_2O

If anhydrous condition, $NaAlSi_2O_6$ is called Zedite.

Heulandite= Lawmontite + Qtz + H_2O (Temp.~ 200·c)

If pressure is more or equal to 3 K-bar (10^3 Bar= 1 K-bar) then

Lawmontite = Lawsonite+ Qtz + H_2O

Lawmontite + Calcite = Prehnite + Quartz + H_2O + CO_2

Laumontite+ Prehnite+ Chlorite = Pumpellyite + Quartz + H_2O

(Upper Temperature Limit):

Upper temperature limits relates to the breakdown of Lawsonite, Pumpellyite & Prehnite around 400·c which coincide with the lower temp. limit of Green-schist facies.

Kaolinite + Quartz = Pyrophyllite (at temp. 345c-375·c)

Lawsonite + Qtz = Zoisite (Epidote)+ Pyrophyllite+ H_2O

Pumpellyite + Qtz = Prehnite+ Epidote + Chlorite + H_2O

Prehnite + Chlorite + Qtz = Epidote + Actinolite + H_2O

(Upper Pressure Limit):

These facies are found in crustal tectonic setting or subduction zone.

Albite = Jadeite + Qtz (At 200·c/ 7.5 k-bar & 300·c/ 9.5 k-bar)

Calcite = Aragonite ($Caco_3$), 180·c/ 5 k-bar & 300.c/ 7 k-bar.

Chlorite + Albite = Glaucophane + H_2O (
pressure limit- less or equal 8 k-bar,

Temperature limit- 200 to 400 ·c

(Green-schist Facies):

1. (Chlorite zone):
   Kaolinite + Quartz ↔ Pyrophyllite + H_2O, (
   at 325·c/ 1 k-bar)
2. (Biotite zone):
   Garnet is produced in the Biotite zone or
   Bouravian zone.
   Microcline + Chlorite = Biotite + Muscovite+
   Quartz + H_2O
3. (Garnet Zone):
   Fe-Chlorite + Quartz = Almandine+ H_2O
   Chlorite + Muscovite + Quartz= Mg-chlorite
   + Biotite + Garnet + H_2O
   (Pressure-Temp. conditions of
   metamorphism):

Lower temperature limit: Temperature ranges between 400·c to 455·c & near about 400·c

(Upper temperature limit):

Temperature~ 550·c

Chlorite + Muscovite = Staurolite+ Biotite + Quartz

Chloritoid + Kyanite = Staurolite + Quartz + H_2O

Mn-chlorite + Quartz = Spessartite + H_2O

(Lower pressure limit):

Albite + Quartz = Jadeite

Chlorite + Albite = Glaucophane, at 4 k-bar pressure.

(pressure-Temperature Regime):

Temperature~ 400·c to 550·c

Pressure~ 4 to 8 k-bar

When we go from north to southIndia, grade of metamorphism inceases.

Granulite facies contain minerals assemblages, charnokite, kodurite & khondalite, present in south India. These facies are fresh and hard.

- (Amphibolite Facies):

  Zones - Subfacies

1. Staurolite zone- Staurolite- Almandine
2. Kyanite zone- Kyanite-Almandine-Muscovite
3. Sillimanite-muscovite zone- (Sillimanite-Almandine- Muscovite)
4. Sillimanite-Orthoclase zone- Sillimanite-Almandine- orthoclase)

Discovered by Hoschok in 1969.

Chloritoid+ Kyanite = Staurolite+ Quartz+ H_2O

Muscovite+ Chloritoid+ Almandine = Staurolite+ Biotite+ H_2O, (at temperature~550·c & pressure 4 to 7 k-bar.