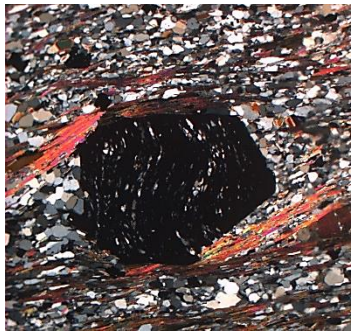
Petrogenesis of Eclogites

M.Sc. Semester II



M. K. Yadav
Assistant Professor
Department of Geology
Lucknow University-226007
Email: mkyadav.geo@gmail.com

Eclogites

- Eclogites are mafic metamorphic rocks that contain a green clinopyroxene called omphacite and Mg-garnet called pyrope.
- Eclogite is an unusually highly dense rocks having basaltic bulk composition.
- Pyroxene are rich in Omphacite together with Jadeite and Diopside.
- Garnets are rich in Pyrope together with Almandine and Grossularite.
- Minor accessories include Kyanite, Rutile, Corundum, Phlogopite.
- Plagioclase is not stable in eclogites.
- Eclogites represent the highest pressure of metamorphism.

Importance of Eclogites

Eclogites have some specific characteristics, which are not present in many rocks and many facies. Therefore, study of Eclogite is very important for following reasons:

(i) Eclogite forms at pressures greater than those for the typical crust of the Earth (such conditions are found in the mantle or the lower most part of thickened crust).

(ii) Eclogites are helpful in explaining the processes and patterns of plate tectonics because many eclogites represent oceanic crust that has been subducted to depths of 35 km and then returned to the surface.

Importance of Eclogites

(iii) Eclogites being an usually dense rock may have important role in driving convection within the solid Earth.

(iv) Many diamonds from eclogite xenoliths have a $^{13}C/^{12}C$ isotope ratio different from that typical of diamonds from peridotite xenoliths. The carbon isotopic differences between harzburgitic and eclogitic diamonds supports the hypothesis that those eclogite xenoliths formed from Basalt carried down within subduction zone.

Factors controlling petrogenesis of Eclogites

(i) **P-T factor:** Eclogites are formed at pressure more than 12 kbar (1.2 GPa) (~ 45 km depth) and temperature 400°C- 1000°C (generally, > 600-650 °C) . This is extremely high pressure and medium to high temperature condition. Under such conditions diamond and coesite also occur in some eclogites. Thus, Eclogite facies can also be considered as a special type of UHP metamorphism.

(ii) **Facies factor:** Eclogite facies is determined by T and P conditions required to metamorphose the basaltic rocks. Under such facies conditions the typical minerals formed are clinopyroxene (dominantly omphacite) and garnet (Pyrope and almandine). Eclogite is the highest pressure metamorphic facies and it usually results from the advancement from Blueschist metamorphic condition.

Patterns of Petrogenesis of Eclogites

(a) Based on Mineral Paragenesis:

- The Eclogite facies is marked by the development of characteristic mafic mineral assemble Omphacite (an Augite-Jadeite solution) + Almandine-Pyrope-Grossular.

- Together they result in dense rock eclogite.

- The eclogite facies represent pressure at which Plagioclase is no longer stable.

- The Albite components of Plagioclase breakdowns in the Blueschist facies and produces Glaucophane.

The Blueschist facies to Eclogite facies transition involves the following reactions that is characteristic of Eclogite facies:

Glaucophane + Plag = Pyrope + Jadeite + Qtz + H_2O (>12 kbar pressure) -------- (i)

At higher temperature and at increasing pressure:
Plag + Amph + Opx + Olivine = Omphacite + Pyrope -------- (ii)

Patterns of Petrogenesis of Eclogites

(b) Based on Plate Tectonic Process:

D.A. Carswell (1990) classified eclogites on the basis of equilibration temperature into following three categories:

(i) Group A eclogites (High temperature eclogites; 900-1000 °C)
Mode of occurrence: inclusions/xenoliths in kimberlites, basalts, or layers in ultramafic rocks.

(ii) Group B eclogites (Medium temperature eclogites; 550 °C-900 °C)
Mode of occurrence: bands or lenses within migmatitic gneissic terrains.

(iii) Group C eclogites (Low temperature eclogites; 450°C-550 °C)
Mode of occurrence: bands or lenses within alpine-type metamorphic rocks (blueschists).

Group A Eclogites

- These are high temperature eclogites and represent subducted oceanic crust that have been reincorporated into mantle and then picked up by rising magmas.

- A variety of anhydrous minerals occur in them including coesite and diamond. The pyrope content of garnet for Group A Eclogite is greater than 55%.

Group B Eclogites

- These occur as lenses in high grade gneisses.
- Most of them are medium temperature eclogites and contain Quartz, Kyanite, Zoisite, aragonite.
- The Pyrope content is 30-55%. The surrounding rocks of this group are Granulite facies and Amphibolite facies.

Group C Eclogites:

- These are typical eclogites from subduction zones that are tectonically mixed and disrupted by metamorphism.

- Epidote, Zoisite and Quartz are typical minerals and Pyrope content of garnet <30%.

- The bulk compositions range from olivine basalts for Group A to tholeiitic basalts for Group C.

- The Jadeite content progressively increase from Group A through Group B, whereas the diopside context decreases.

- The Ca/Mg ratio increases in garnet and decreases in pyroxene from Group A through Group B eclogites.

Petrogenetic models of Eclogites:

Eclogites may have a variety of origins. With the help of petrology, plate tectonics and fields observation, a few models have been proposed for petrogenesis of eclogites.

Model 1: High grade metamorphism of mafic igneous rocks, when crust plunges to the mantle:

Various evidence suggest that about 7% of mantle may be eclogite. According to this model, eclogites form at high pressure by the metamorphism of mafic igneous rocks (basalt, gabbro).The eclogites form when the crust plunges into the mantle in a subduction zone. Such eclogites are generally formed from precursor mineral assemblages of Blueschist facies metamorphism.

Petrogenetic models of Eclogites:

Model 2: Remnants of subducted oceanic crust:

Eclogites may be produced by high pressure crystallization. In this model, eclogites are considered as remnants of subducted oceanic crust or the residue of partial melting of such crust.

Model 3: Metamorphic products of Gabbroic or Anorthositic protoliths:

Some eclogites may be products of metamorphism of mafic lower continental crustal rocks i.e. gabbroic to anorthositic protoliths and some eclogites may be high pressure garnet- pyroxene accumulates.

Model 4: High MgO eclogites may represent the lower parts of subducted oceanic crust or mafic lower continental crust.

Thank You

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