BSc (IV) semester: Lecture Notes (Prof. S. Sensarma)

Regional Metamorphism of Pelitic Rocks

During Regional metamorphism of pelitic rocks (e,g, shale, a common sedimentary rock, rich in clay minerals (Al-rich), typical metamorphic mineral assemblage and associated textural changes/fabric development are as follows:

Chlorite zone: Pelitic rocks metamorphosed to slates/phyllites and typically contain chlorite + muscovite + quartz + albite (Na-plagiocalse). Rock is fine-grained and develops slaty cleavage.

Biotite zone: Slates change over to phyllites and schists and contain biotite + chlorite + muscovite + quartz + albite. Phyllites show phyllitic sheen. Grain size increases in schists.

Garnet zone: Schists develop red almandine garnet, and usually with biotite, chlorite, muscovite, quartz, and albite or oligoclase (Na-Ca plagioclase). Development of schistosity characterises schists.

Staurolite zone: Schists with staurolite; biotite, muscovite, quartz, garnet, and plagioclase are other common minaerals. Chlorite may occur in some cases. Schistosity is pronounced and closer spaced.

Kyanite zone. Schists with kyanite; other minerals include biotite, muscovite, quartz, plagioclase, garnet and staurolite

Sillimanite zone. Schists and gneisses are common rocks with sillimanite; other minerals include biotite, muscovite, quartz, plagioclase, garnet, and occasionally staurolite. Some

kyanite may also be present. Gneisses are coarser grained and develop alternate bands of dark (mafic) and light coloured (felsic) minerals during metamorphism (gneissosity).

Regional Metamorphism of Mafic Rocks

Plagioclase and pyroxene are two common minerals in mafic rocks (e.g., gabbro/basalt). The Ca-rich plagioclase become progressively unstable as temperature is lowered. In greenschist facies condition, common minerals include chlorite + albite + actinolite (amphibole) + epidote + quartz ± calcite ± biotite ± stilpnomelane. In the greenschist facies, oligoclase becomes stable. The An-content of plagioclase increases as metamorphic grade increases. Chlorite + actinolite + epidote impart green colour to the rock called greenstone, and facies name given is greenschist facies.

Greenschist to amphibolite facies involves two major mineralogical changes major mineralogical changes: (a) albite to oligoclase (increased Ca-content of plagioclase with temperature), and (b) actinolite change over to hornblende (Al-rich amphibole) at higher temperatures.

The granulite facies is characterized by the presence of a largely anhydrous mineral assemblage in granulite Facies condition. Critical mineral assemblage is orthopyroxene + clinopyroxene + plagioclase + quartz + garnet + minor hornblende. More calcic plagioclase are stable in amphibolite and granulite facies condition.

Under blueschist facies condition, mafic rocks are recognizable by their bluish colour and characterized by the presence of sodic blue amphibole glaucophane (+ quartz), stable only at high pressures. In Eclogite facies, metamorphosed mafic rocks have mineral assemblage omphacitic pyroxene (green coloured) + garnet (red).

Regional Metamorphism of Calcareous Rocks

Marbles

The term marble is used for metamorphosed calcareous rocks in which carbonate minerals are the dominant phases. Many marbles are composed only of calcite + minor quartz and phyllosilictes (commonly mica). Graphite may sometimes be present from organic debris. Pyrite may also a common accessory mineral. Calcite is stable in all conditions except at highest pressures (Fig. 7).

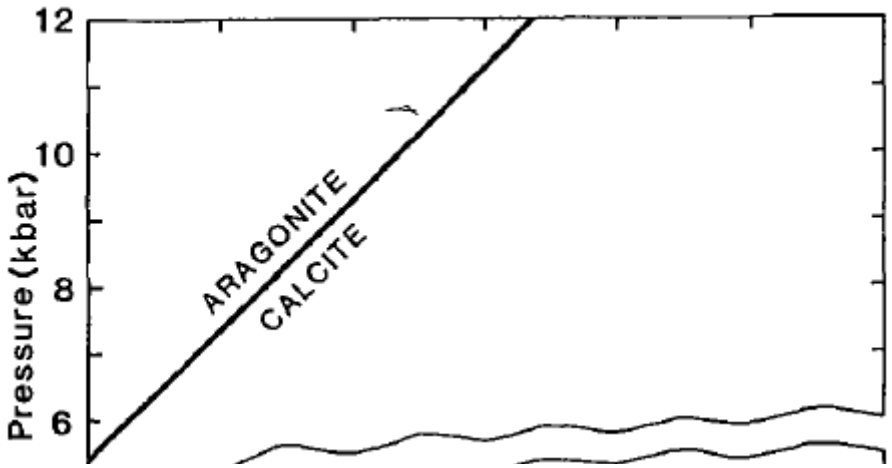

Fig. 7. showing pressure stability filed of calcite-aragonite (modified after Yardley, 2009)

At very high temperatures and low pressures, calcite may react with quartz present in the rock producing calcium silicate, wollastonite (ca-rich pyroxene) and CO_2.

$CaCO_3 + Si0_2 \rightarrow CaSiO_3 + CO_2$

This is called a decarbonation reaction and is a common type of reaction.

Extensive textural changes take place due to recrystallisation of calcite to produce a coarser grain size and occasionally a preferred orientation.

Calc-silicate rocks

Calc-silicates rocks are defined as being rocks rich in Ca-Mg-silicate minerals (e.g., Ca-Mg pyroxene), but with only minor amounts of carbonate. Because calc-silicates contain significant amounts of other chemical components especially Al, K and Fe, their mineralogy is more complex than that of dolomitic marbles. Common minerals include zoisite, garnet, hornblende, calcic plagioclase, K-feldspar.

The major mineralogical change observed in the calc-silicates is the appearance of calcic amphibole coexisting with K-feldspar, through the reaction:

biotite + calcite + quartz--> Ca-amphibole + K-feldspar + CO_2+ H_2O

Anatexis

High grade metamorphic rocks, which form at a temperature >600°C, may undergo partial melting to produce magma; thus domain of metamorphism gives over to the domain of magmatism (igneous processes). The degree of partial melting and the melt composition vary and depend on the bulk composition (hence mineralogical assemblage) of the high grade rocks. This type of partial melting of metamorphic rocks in the continental crust is called Anatexix. The resulting partially melted rocks are called migmatites (see also in lecture on migmatitite earlier), which means 'mixed rocks'. Many granites are products of anatexis. Both metamorphic and igneous processes contribute to its evolution.

Concluded...