Chapter III

PETROGRAPHY AND METAMORPHISM

Among the metasedimentary rocks of the area concerned, phyllites are the most widespread. They are, however, in a highly weathered state and have largely been altered into laterites, sometimes of considerable thickness. This was in fact a serious handicap in the field for any systematic attempt to collect fresh samples of phyllites for petrographic studies. However, as far as practicable, attempts were made to pick up the desired samples from the few outcrops of phyllites which were still fresh or weathered partly. Collection of rock samples from other formations, such as ferruginous quartzites, dyke rocks, etc., did not however, pose such a problem.

The following important rock types have been chosen for petrographic studies :

i) Chlorite phyllites

ii) Calcareous phyllites

iii) Banded ferruginous quartzite

iv) Basic rocks

PETROGRAPHIC DESCRIPTION

Chlorite phyllites

Most of the minerals composing the chlorite phyllites are too small to be distinguished magascopically. Under the microscope the rocks appear to be schistose and fine-grained with some porphyroblasts of quartz and felspar (Plate II, fig.1). The finer grained minerals are quartz, felspars, flaky mica and chlorite.

Granular or scaly opaque iron oxides are randomly distributed throughout the ground mass. Zircon and tourmaline, probably detrital minerals, occur very rarely. Very minute crystals of apatite and zircon also occur as inclusions in the porphyroblasts of felspars and, less commonly, in quartz.

Quartz.- The porphyroblasts ofquartz are mostly rounded to subrounded (Plate II, fig.2) with some of them slightly elongated. The longer axes of such grains are usually oriented parallel to the foliation direction of the phyllites (Plate II, fig.1). Some of the prophyroblasts are fractured. Due to recrystallization most of their original crystal boundaries were obliterated beyond any recognition. Strain shadow is a characteristic feature of this quartz. Sometimes aggregates of finer-grained quartz occur locally. The grains have sutured boundaries along which they are interlocked (Plate II, fig.3).

Felspar.- Albite happens to be the common variety of felspar in the phyllites. Porphyroblasts of albite are quite abundant and sometimes their quantity seems to be a little higher than that in the normal pelitic rocks. Both twinned and untwinned varieties of albite are present, of which the untwinned ones are predominant. Their shape varies from anhedral to subhedral. Minute inclusions of micas, chlorite, apatite, etc., are generally abundant in the albite and in a few cases inclusions are so much crowded that a sort of sieve structure is formed (Plate II, fig.4).

Flaky Minerals.- Aggregates of flaky minerals like muscovite, chlorite and sericite are so common in the phyllites that their presence has made the rock cleavages conspicuous. Biotite is very rare. Occasionally, these flaky minerals are segregated along distinct bands (Plate III, fig.1). Some of the flaky minerals are deformed and bent around the porphyroblasts of quartz and albite. Sericite and muscovite also occur as inclusions commonly in albite but rarely in quartz.

Opaque Minerals.- Magnetite and hematite are the two opaque minerals associated with the phyllites. The shape of magnetite grains is either octahedral or elongated whereas hematite occurs either in granular or scaly form. Both of them are distributed randomly throughout the thin section.

Zircon.- There are a few minute crystals of zircon with rounded to subrounded shape, which indicates original detrital nature of the mineral.

Calcareous phyllites

This variety of phyllites is very fine-grained, comparatively more compact and hard, and less distinctly foliated than the chlorite phyllites. The rock is essentially composed of some coarser-grained calcite, felspar and quartz which are enclosed in a sub-microscopic matrix composed of finer-grained quartz, felspars, micas and chlorite. Iron oxides are distributed throughout the sections. There are also a few grains of zircon.

Calcite.- Calcite occurs quite frequently as irregular aggregates of crystals which are mostly subhedral to anhedral (Plate III, fig.2). Sometimes, the crystal aggregates form imperfect segregation bands. Change of relief is well-marked in calcite and often its crystal boundaries and cleavage partings are stained brown due to alteration.

Quartz.- The quartz porphyroblasts are so arranged that their major axes are parallel or subparallel to the foliation trend of the phyllites. The porphyroblasts invariably display strain shadow and are recrystallized but without showing any sign of outgrowth in thin section. A few of the porphyroblasts have retained partly their clastic nature.

Felspar.- Albite is the most common variety of felspar met with. The crystals are subhedral to anhedral and subangular to subrounded in shape. A few of the crystals show lameller twinning but the rest is untwinned. The porphyroblasts are riddled with minute inclusions of micas, apatite and, rarely of zircon (Plate III, fig.3).

Flaky Minerals.- Muscovite and chlorite are the common flaky minerals. Sometimes, aggregates of these minerals are segregated into imperfect bands. Some chlorite and muscovite are also deformed and bent around quartz and felspar porphyroblasts as in chlorite phyllites. Biotite is rather subordinate and shows a distinct preferred orientation (Plate III, fig.4). Uniaxial mica occurs as inclusion in albite and quartz porphyroblasts.

Opaque Minerals.- Most thin sections have patches of dark brown iron oxides, confined mostly around calcite grains. In addition, there are some minute grains or scales of dark iron oxides.

Zircon.- Rarely a few rounded to subrounded minute crystals of zircon, probably detrital, occur in the rock. Minute crystals of zircon also occur as inclusions in the felspar and quartz porphyroblasts.

Banded Ferruginous Quartzite

Usually, the banded ferruginous quartzite has alternating dark ferruginous and white siliceons bands (Plate IV, fig.1). Thin section study shows that the white bands are made up of cherty quartzite and the darker ones of iron oxides. The central part of each siliceons band has very little of iron oxides but as the adjacent dark bands are approached the proportion of iron oxides increases (Plate IV, fig.2).

The quartz grains in the siliceons bands are more or less equigranular, very fine-grained and occasionally cherty in nature (Plate IV, fig.3). On the average, grain size of quartz varies from 0.16 mm to 0.4 mm. The interlocking grains of quartz have sutured margins showing mosaic texture (Plate IV, fig.4). In ordinary light, grain boundaries are hardly redognisable due to the absence of any intergranular matrix. However, in certain cases, partial replacement or staining of the grain boundaries by a brown iron oxide, helps demarcate individual grains (Plate V, fig.1). Strain shadow effect is a characteristic optical property of this quartz. Quartz grains also have some dusty inclusions and specks of iron oxides.

The ferruginous bands consist mainly of euhedral to subhedral magnetite with subordinate amounts of quartz (Plate V, fig.2). In a few thin sections of these bands the amount of quartz is is considerably high. The grain size of magnetite varies from 0.09 mm to 0.26 mm. Scaly and prismatic grains of hematite are often oriented parallel to the plane of schistosity which is crudely developed (Plate V, fig.3).

Basic Rocks

There are several outcrops of basic intrusives, including some metadolerites, which occur along the Bicholim and Valvota rivers north of Bicholim and Sanquelim townships respectively. In physical appearance, the younger dykes differ little from the older metadolerites, except in the grain-size. However, they differ markedly in their mineral constituents, textures, structures etc., visible in thin section only. It is on this basis that they have been classified as 1) metadolerite and 2) dolerite. The metadolerites are foliated and either epidote bearing or epidote free whereas the dolerites are unfoliated and may or may not have olivine among other mineral constituents.

Metadolerite.- The rock is commonly composed of plagioclase and hornblende with subordinate amounts of chlorite, sphene and iron oxides. Calcite and quartz are more subordinate. Frequently the rock exhibits granoblastic texture (Plate V, fig.4) but the blastophitic texture was also seen in some sections (Plate VI,fig.1). In general, schistosity is not so well developed. However, some rocks appear to be crudely foliated due to subparallel alignment of prismatic or streaky crystals of hornblende.

Plagioclase is commonly represented by the variety albite which is either subhedral or anhedral. Subhedral crystals frequently show carlsbad and rarely albite twinning. Undulatory extinction may commonly be seen in the felspars. Plagioclases are partly altered into epidote and zoisite (Plate VI, fig.2).

Hornblende is either prismatic or fibrous with a pale green colour, faintly pleochoric from greenish brown to olive green colour. One set of imperfect cleavage in porphyroblastic hornblende is more common than two sets of rhombic cleavages. The actinolite and uralite which occur along with some chlorite around the hornblende crystals are alteration products of latter (Plate VI, fig.3). At places, intensely clouded patches, probably of original augite, are associated with hornblende. Both twinned and untwinned crystals of hornblende may be seen in thin sections.

Anhedral or subhedral epidote occurs in considerable amount in some thin sections while in others they are insignificant. The granular epidote commonly forms clusters in felspar while the subhedral one, which is comparatively of large grain-size, occurs scattered or in aggregates (Plate VI, fig.3). Zoisite is less common than epidote. It occurs either as inclusions in albite or associated with epidote. Sphene, which is still rare, is granular. Some opaques usually form the core of sphene.

The groundmass is very fine-grained and almost submicroscopic. It consists of flaky amphiboles, chlorite, some granular felspar, epidote and zoisite. Sphene, quartz and calcite are uncommon.

Dolerite.- Megascopically both the varieties viz., olivine-bearing and olivine-free dolerites are dark grey in colour, medium-grained, hard and compact. The rocks show presence of lustrous plates of plagioclase and darker pyroxene.

Laths of plagioclase felspars and large plates of pyroxene are generally so disposed that they exhibit a typical ophitic texture (Plate VI,fig.).

Felspar is generally represented by andesine which is either lath-shaped, tabular or subhedral. Carlsbad twinning is by far the most common. A few of them are partially kaolinised due to which they have a clouded appearance (Plate VII,fig.1).

Pyroxene, when fresh, is represented by subhedral to anhedral augite. Occasionally augite alters to pale green and scaly aggregates of chlorite,formed particularly around its crystal boundaries. Both twinned and untwinned crystals of augite are present. The mineral has ordinarily one set of cleavage but in some cases two sets nearly at right angles are also seen.

Olivine, wherever occurs, is either anhedral or subhedral. Initial stage of alteration is indicated by the appearance of serpentine along irregular network of fractures in olivine. In a few cases alteration is so advanced that only a few relict patches of olivine remain in a mass of serpentine (Plate VII,fig.2). The other alteration product of olivine is iddingstite.

Both chlorite and biotite are generally associated with augite and less commonly with felspars.

METAMORPHISM

The mineralogical assemblage and petrographic characters of the phyllites and associated banded ferruginous quartzites of the area reveal that they are essentially metasedimentary rocks originated as a result of regional metamorphism of ancient sediments composed largely of argillaceous materials, with the occasional presence of lenses of highly ferruginous psammites. Deformation and regional stress were probably responsible for chemical adjustment of the rocks to temperature and pressure (see Turner and Verhoogen, 1962, p.669). The petrography of the metamorphosed pelitic rocks suggests that their grade of metamorphism is low and equivalent to the chlorite zone (see Harker, 1960, p.209) or quartz-albite-muscovite-chlorite subfacies of greenschist facies (see Turner and Verhoogen, 1962, p.534). Metamorphosed basic rocks also testify to the above grade of metamorphism. The appearance of biotite in the calcareous phyllites evidently registers some advancement of metamorphism to the biotite zone of the greenschist facies (see Harker, 1960, p.214). The banded ferruginous quartzites are conspicuously free from any iron silicate or any other silicate mineral of metamorphic origin. The rock is typically composed of magnetite - chert with some specular hematite. The rock owes its banding to the original depositional feature of the sediment. In some quartzites a crude schistosity is developed on account of orientation of iron oxide minerals parallel to the strike of the bands. All these mineralogical, structural and textural features may be attributed to regional metamorphism of iron formation (see James, 1955) composed of almost equal proportion of ferruginous and silicenous materials. It is also evident from the mineralogical assemblage that the grade of metamorphism is low and belongs to the chlorite division of the greenschist facies (see Pascoe, 1950, p.80).