CHAPTER - VIII

DYKE ROCKS

INTRODUCTION:

The dyke rocks are represented by dolerites in the thesis area. The field and petrographical characteristics of dolerites are presented in this chapter and their probable parental magma traced.

FIELD CHARACTERISTICS:

The distribution of dolerite dykes around Chetput is shown in Fig. 28. In the northern zone of the western division, dolerite dykes occur in the vicinity of Nandipuram. It intrudes into enderbite and is about 500 meters in length and about 1.5 meters wide. It trends in a WNW - ESE direction and has vertical dips. It is an aphanitic, dark grey, dense rock with slender laths of pale grey feldspars set in a very fine-grained groundmass.

About one kilometer east of Teppirampattu, two bands of porphyritic dolerite occur as dykes in enderbite (Plate XI, Fig. 1). They are each about 500 meters long and about two meters in width. These
SKETCH MAP SHOWING THE DISTRIBUTION OF DOLERITE DYKES OF THE THESIS AREA

EXPLANATION

- **Dolerite**
- **Pink granite, Pegmatite and Aplite**
- **Dark grey granodiorite gneisses**
- **Dark grey granodiorite gneisses with porphyroblasts of plagioclase**
- **Amphibolites**

**Legend**
- **E** Enderbite
- **BC** Basic member of Charnockite Series
- **BG** Biotite gneiss
- **C** Cordierite gneiss
- **M** Magnetite-Quartz rock
Their contacts with the country rock are quite sharp and their grain size is fine along the contacts. In the middle portion, however, they show increase in grain size, and are comprised of slender laths of feldspars and dark glistening grains of pyroxenes. They also trend in a WNW - ESE direction. Their lengths vary from a few meters to more than two kilometers and their width varies from a few meters to about ten meters. West of Valatti there occurs a dolerite dyke about three kilometers long and about ten meters in width intruding all the earlier rocks. It is a medium-grained, dense, dark grey rock characterised by slender laths of pale grey plagioclase and dark glistening grains of pyroxenes. Quartz occurs interstitial to plagioclase.

In the southern zone of the central division there are only a few occurrences of dyke rocks and their trend varies from NW - SE to WNW - ESE.

In the central zone of the eastern division there are only a few occurrences of dykes. They are
bouldery in nature and are medium-to fine-grained. They exhibit spheroidal weathering (Plate XI, Fig. 3). The dyke occurring west of Melolakkūr is olivine dolerite while the dyke occurring near Kallapuliyyūr is a bronzite dolerite. It is worthy of note that all the dyke occurrences in the thesis area trend in the NW - SE to WNW - ESE and have intruded along the joint planes of the older rocks.

PETROGRAPHY:

Petrographically the dolerite dykes of the thesis area can be classified as (a) Chilled phases of dolerite, (b) Fine-grained dolerites, (c) Porphyritic dolerites and (d) Medium-grained dolerites.

(a) CHILLED PHASES OF DOLERITE:

The chilled phases of the dolerite comprise (i) Vitrophyric dolerite and (ii) Pilotaxitic dolerite.

(i) VITROPHYRIC DOLERITE:

It is a compact, dense, dark grey aphanitic rock (G J. 36).
PLATE-XI

Fig. 1. Field photograph of porphyritic dolerite dyke, east of Teppirampattu.

Fig. 2. Field photograph of sharp contact between dolerite dyke and dark grey granodiorite gneiss, near Kodukkankuppam.

Fig. 3. Field photograph of dolerite showing spheroidal weathering in the central zone of the eastern division.
Under the microscope, phenocrysts of plagioclase and pyroxene are present in a glassy groundmass. Plagioclase is in the form of laths varying in length from 1.2 mm to 0.6 mm, and in width from 0.13 mm to 0.17 mm. The plagioclases are twinned mostly after Carlabad or albite-Carlsbad laws. The anorthite content varies between 65 and 75 per cent. Dark glassy material sometimes occurs along the twinning lamellae of plagioclase. Interpenetration twins of plagioclase are not uncommon. Augite occurs as euhedral to subhedral crystals and varies in length from 0.1 mm to 0.4 mm. A few grains are twinned on (100). \( 2V_Z = 51^\circ; Z \wedge C = 41^\circ. \) The glassy material also occurs along the cleavage planes of augite as streaks.

(ii) **PILOTAXITIC DOLERITE:**

It is a dense, dark grey, aphanitic rock (G J. 116).

Under the microscope, the rock shows a pilotaxitic texture due to the presence of plexus of plagioclase in glassy groundmass (Plate XII, Fig. 1). Phenocrysts of plagioclase varying in length from 1.1 mm to
0.7 mm are present. They are mostly twinned after Carlsbad and albite-Carlsbad laws. The anorthite content varies from 70 to 75 per cent. There are a few grains of plagioclase which show normal zoning in which the core has an anorthite content of 75 per cent and the mantle 65 per cent. Euhedral and subhedral phenocrysts of augite are present. They are colourless and usually display twinning on (100). $2V_z = 52^\circ$; $Z\ A\ C = 42^\circ$. The groundmass contains plexus of plagioclase. The anorthite content of few twinned laths is 65 per cent. Pyroxenes occur as glomer porphyritic group in the groundmass. Both pigeonite and sub-calcic augite are present. Pigeonite is pale green in colour. $2V_z = 25^\circ$ to $29^\circ$. Sub-calcic augite is colourless. $2V_z = 37^\circ$ to $41^\circ$; $Z\ A\ C = 41^\circ$. Sometimes, it wraps around augite and pigeonite. Opaque ore occurs as an accessory.

The variation of the above type shows, under the microscope, slender, radiating plexus of plagioclase and radiating tufts of augite. Euhedral and subhedral crystals of enstatite occur as phenocrysts. $2V_z = 86^\circ$. They are colourless and sometimes carry inclusions of
olivine. Plagioclase occurs as radiating, slender laths and display twinning lamellae. The anorthite content is 70 per cent. Stumpy prisms of augite sometimes occur in association with radiating tufts of augite. They are colourless and occasionally twinned on (100). $2V = 51^\circ$; $Z \wedge C = 43^\circ$. Opaque ore occurs as a prominent accessory.

(b) **FINE-GRAINED DOLERITES:**

Fine-grained dolerites are represented by (i) Olivine dolerite and (ii) Enstatite dolerite.

(i) **OLIVINE DOLERITE:**

It is a dark, fine-grained, dense rock consisting of slender pale grey laths of plagioclase and dark glistening pyroxenes associated with deep green olivine (G J. 20, 24 and 47).

In thin slice, it shows ophitic texture (Plate XII, Fig. 2). Olivine occurs both as euhedral and subhedral crystals and occasionally shows sharp resorption borders. Sometimes, the presence of dusty inclusions renders it pale brown.
2 V_z = 87^0; N_y = 1.690. Enstatite occurs as colourless crystals and sometimes wraps around olivine. In a few places, it is mantled by augite. Augite is colourless and occurs both as euhedral and subhedral crystals. A few grains are twinned on (100).

2 V_z = 51^0; Z \wedge C = 42^0. Plagioclase occurs as slender laths and has an anorthite content 65 to 75 per cent. It is mostly twinned after albite-Carlsbad and Carlsbad laws. Opaque ore occurs as lumps and is often associated with olivine.

In a variation of the above type, olivine shows alteration to serpentine and the cracks are filled with opaque ore.

(ii) ENSTATITE DOLERITE:

It is a fine-grained, dark grey, dense rock consisting of pale grey feldspar and dark, glistening pyroxene (G J. 78 and 89).

Under the microscope, it displays ophitic texture. Laths of plagioclase are fresh and are twinned on albite-Carlsbad and Carlsbad laws. Its
anorthite content varies between 55 and 65 per cent. Enstatite occurs as prismatic plates and is colourless. \(2V_z = 87^\circ\); \(N_z = 1.681\). Augite is colourless and is often twinned on (100). In some grains (100) twinning lamellae are very prominent. \(2V_z = 51^\circ\); \(Z\AA C = 42^\circ\). Sometimes, sub-calcic augite wraps around augite, but commonly sub-calcic augite occurs interstitial to plagioclase and augite. \(2V_z = 37^\circ\); \(Z\AA C = 41^\circ\). Lumps of opaque ore occur as accessories.

(c) PORPHYRITIC DOLERITE:

It is characterised by phenocrysts of grey plagioclase embedded in dark grey groundmass consisting of slender laths of pale grey plagioclase, dark green olivine and dark grey pyroxene (G J.49, 50 and 92)

Under the microscope, this rock shows porphyritic texture (Plate XII, Fig. 3). Phenocrysts of plagioclase show polysynthetic twinning lamellae and have an anorthite content of 70 per cent. They carry inclusions of opaque ore and minute grains of olivine. The groundmass consists of laths of plagioclase varying
in anorthite content from 60 to 65 per cent and twinned mostly on albite-Carlsbad and Carlsbad laws. Olivine occurs as discrete grains and is euhedral to subhedral carrying minute inclusions of opaque ore. $2V_z = 87^\circ$; $N_y = 1.690$. Enstatite occurs marginal to olivine. $2V_z = 84^\circ$; $N_z = 1.681$. Augite is colourless and sometimes wraps around enstatite. $2V_z = 52^\circ$; $Z \Lambda C = 42^\circ$. Sub-calcic augite occurs in association with augite. $2V_z = 36^\circ$; $Z \Lambda C = 40^\circ$. Opaque ore is the prominent accessory.

(d) MEDIUM-GRAINED DOLERITES:

The following are recognized under medium-grained dolerites. (i) Olivine-bronzite dolerite, (ii) Bronzite dolerite with micro-pegmatite, (iii) Dolerite with micro-pegmatite and (iv) Quartz dolerite.

(i) OLIVINE-BRONZITE DOLERITE:

It is a medium-grained, dark grey, dense rock with pale grey laths of plagioclase, granular green olivine and dark pyroxenes (G J. 90).
In thin slice, it shows a sub-ophitic texture. Olivine is euhedral to subhedral and carries dusty brown inclusions. \(2V_Z = 88^\circ; N_y = 1.691\). Enstatite is sparingly present marginal to olivine and is colourless. \(2V_Z = 83^\circ\). Bronzite occurs as prismatic plates and grains and is feebly pleochroic from pale pink to pale green. \(2V_Z = 82^\circ; N_z = 1.680\). Augite is colourless and sometimes twinned on (100). \(2V_Z = 51^\circ; N_y = 1.693\). Sub-calcic augite sometimes wraps around augite. \(2V_Z = 37^\circ;\ Z\ A\ C = 41^\circ\). Laths of plagioclase are well twinned and have an anorthite content varying from 60 to 65 per cent. Opaque ore is marginal to pyroxenes. Biotite is an occasional accessory and is associated with opaque ore.

(ii) **BRONZITE DOLERITE WITH MICRO-PEGMATITE:**

It is a medium-grained, dark grey, dense rock with pale grey plagioclase and dark grey pyroxenes (G J. 102).

Under the microscope, the rock exhibits sub-ophitic texture. Laths of plagioclase are commonly clouded with inclusions of fine dust. It displays
twinning on Carlsbad and albite-Carlsbad laws. A few plagioclase grains show normal zoning with a core having an anorthite content of 60 per cent and the rim 55 per cent. Micro-pegmatitic intergrowth of quartz and orthoclase is observed interstitial to laths of plagioclase. Broad anhedral grains of orthoclase sometimes occur in micro-pegmatite. $2V_x = 48^\circ$. Bronzite occurs as elongate prismatic plates and is clouded due to presence of dusty inclusions. $2V_z = 80^\circ$; $N_z = 1.677$.

Augite is colourless and occurs as prismatic plates and grains. $2V_z = 52^\circ$; $Z \Lambda C = 41^\circ$; $N_y = 1.693$. Ferriferous sub-calcic augite occurs marginal to augite. $2V_z = 40^\circ$; $Z \Lambda C = 41^\circ$; $N_y = 1.710$. Hornblende is rare and occurs marginal to ferriferous sub-calcic augite. Opaque ore occurs as an accessory.

(iii) **DOLERITE WITH MICRO-PEGMATITE:**

It is a medium-grained, dark grey rock with slender-laths of pale grey feldspar and dark grey granular pyroxene (G J. 111).

Under the microscope, the rock shows a subophitic texture. Plagioclase occurs as broad laths
and is fresh and clear. They are twinned on albite-Carlsbad and Carlsbad laws. The anorthite content is 55 per cent. Micro-pegmatitic intergrowth of quartz and orthoclase occur interstitial to plagioclase.

Ferro-augite is pale green in colour and occurs as broad prismatic plates. $2\, V_z = 42^\circ$; $Z \wedge C = 42^\circ$; $N_y = 1.719$. Bronzite is rare and is associated with ferro-augite. Ferro-pigeonite sometimes wraps around ferro-augite. $2\, V_z = 29^\circ$; $N_y = 1.689$. A few grains of hornblende occur as an alteration product of ferro-augite. It is pleochroic from pale yellow to bluish green. Laths of biotite are rare and shoot into hornblende. It is pleochroic from straw yellow to dark brown. In the vicinity of micro-pegmatite, brown biotite is altered to green biotite. Opaque ore is an accessory.

(iv) QUARTZ DOLERITE:

It is a medium-grained, dense, dark grey rock characterised by slender laths of pale grey plagioclase and dark glistening grains of pyroxenes (G J. 21, 48, 83 and 93).
In thin section, the rock exhibits a subophitic texture (Plate XII, Fig. 4). Plagioclase occurs as broad laths and is twinned after Carlsbad and albite-Carlsbad laws. Its anorthite content is 50 per cent. Ferro-augite occurs as subhedral crystals and prismatic plates. A few grains are twinned on (100). 2 V_z = 41^\circ; Z \Delta C = 42^\circ; N_y = 1.710. Quartz occurs as anhedral grains interstitial to plagioclase. Hornblende is rare as an alteration product of ferro-augite. It is pleochroic from pale yellow to bluish green. Biotite and chlorite are sparse and occur marginal to hornblende. Lumps of opaque ore are associated with ferro-augite.

The modes of dolerite dykes are shown in Table - XIV.

PETROCHEMISTRY:

The chemical analyses of some important members of the dolerite are shown in Table-XV, together with their Niggli base molecular values. These values match favourably with similar rock types of the Pacific suite.
# TABLE XIV

THE MODES OF THE DOLERITE DYKES OF THE THESIS AREA

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Total: 100.0 100.0 100.0 100.0 100.0

1. G J. 20: Olivine Dolerite  
Locality: 1 Km W of Melolakkur.

2. G J. 116: Pilotaxitic Dolerite  
Locality: Near Nandipuram.

3. G J. 78: Enstatite Dolerite  
Locality: 1 Km N of Kaplambūdi.

Locality: 1.5 Km NE of Eyyal.

5. G J. 48: Quartz Dolerite  
Locality: 500 meters W of Valatti.
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**Total** | 99.87 | 99.77 | 100.53 | 100.28 | 99.81 | 100.08 | 99.66 |

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1. **G J. 20:** Olivine Dolerite  
   Locality: 1Km W of Melolakkär  
   Analyst: E. George Jesudossan.

2. **G J. 116:** Pilotaxitic Dolerite  
   Locality: Near Nandipuram  
   Analyst: E. George Jesudossan.

3. **G J. 36:** Vitrophyric Dolerite  
   Locality: Near Sangilikuppam  
   Analyst: E. George Jesudossan.

4. **G J. 78:** Enstatite Dolerite  
   Locality: 1 K. N of Kaplamadì  
   Analyst: E. George Jesudossan.

5. **G J. 111:** Dolerite with Micro-pegmatite  
   Locality: Near Kallapulyur  
   Analyst: E. George Jesudossan.

6. **G J. 129:** Bronzite Dolerite with Micro-pegmatite  
   Locality: 1.5 Km NE of Eyyal  
   Analyst: E. George Jesudossan.

7. **G J. 48:** Quartz Dolerite  
   Locality: 500 meters W of Valatti  
   Analyst: E. George Jesudossan.
The variation diagram of the analysed rocks showing iron enrichment along the abscissa and the other oxides along the ordinate is shown in Fig. 29. Brammall (1933, p.100), Krokström (1937, p. 271-272) and Wager and Deer (1939, p.226) prefer this diagram to study the differentiation of basic magma. The diagram shows a gradual decrease of MgO, FeO, and CaO with iron enrichment. There is slight decrease of TiO₂ and Al₂O₃ with iron enrichment. Fe₂O₃ rises slightly in the later members and Na₂O, K₂O and SiO₂ increase gradually. The increase and decrease of different oxides with enrichment of iron is consistent with the process of differentiation of a basic magma due to fractional crystallisation.

The ternary variation diagram of Mg⁺⁺-(Fe⁺⁺ + Fe³⁺) - (Na⁺ + K⁺) of the dolerite dykes of the thesis area is shown in Fig. 30. It reveals the role of more refractory and less refractory elements during differentiation. The trend of differentiation of the dolerite dykes is convex upwards. This indicates moderate enrichment of iron during middle and end stages
The behaviour of certain major elements in the dolerites of the thesis area (Fig. 29) is suggestive of differentiation of a mafic magma. The abundance of olivine phenocrysts in the dolerite dykes of the area (Fig. 29, 2) is indicative of differentiation of a basaltic magma. The trend of the FeO/MgO values is suggestive of differentiation of a basaltic magma. The dolerite dykes of the area (Fig. 29, 2) are dominated by mafic minerals, and the MgO content increases with increasing FeO content. The variation diagram of the dolerites of the thesis area (Fig. 29) is plotted against the ratios of FeO + Fe₂O₃ + MgO to FeO + Fe₂O₃. The data points suggest a trend which is convex upwards, indicating a moderate enrichment of lime during the late stage of differentiation.
of differentiation. The ternary variation diagram of $\text{Ca}^{++} - \text{Mg}^{++} - (\text{Na}^+ + \text{K}^+)$ of the dolerite dykes of the area also show a trend which is convex upwards (Fig. 31) suggesting moderate enrichment of lime during middle stage of differentiation.

The behaviour of alkalies shown by the ternary variation diagram of $\text{Ca}^{++} - \text{Na}^+ - \text{K}^+$, for the dolerites of the area (Fig. 32) compares favourably with the trend of Skaergaard.

The Q-L-M diagram of Niggli was prepared for the dolerite dykes of the area (Fig. 33). The trend of the Q, L, M values is suggestive of differentiation of a basic magma.

The abundance of opaque ores in the medium-grained dolerite of the thesis area might perhaps be due to high water content and water vapour in the basic magma which might have assisted in the precipitation of iron oxide during the end stage differentiation of basic magma. This view has been emphasised by Kennedy (1948) and Osborn (1958).
FIG. 30. $(\text{Fe}^{III} + \text{Fe}^{II}) - \text{Mg}^{II} - (\text{Na}^+ + \text{K}^+)$

DIAGRAM FOR DOLERITES OF THE THESIS AREA

FIG. 31. Ca''-Mg''-(Na'+K') DIAGRAM FOR DOLERITES OF THE THESIS AREA
From the above, it is obvious that the various members of the dolerite dykes have resulted from differentiation of a basic magma in order to obtain information about the composition of parent basic magma a few more diagrams were drawn.

**FIG. 32.** Na' - Ca''-K' DIAGRAM FOR DOLERITES OF THE THESIS AREA

**FIG. 33.** Q - L - M DIAGRAM FOR THE DOLERITES OF THE THESIS AREA

○ PLOTS OF THE DOLERITES OF THE THESIS AREA
PETROGENESIS:

From the above it is obvious that the various members of the dolerite dykes have resulted due to differentiation of a basic magma. In order to obtain information about the nature of parent basic magma a few more diagrams were drawn.

Tilley (1950) has plotted alkalies against silica in order to differentiate tholeiites from alkali basalts. A similar diagram prepared for the dolerite dykes of the thesis area shows a trend matching with that of Hawaiian tholeiites (Fig. 34). Murata (1960, p. 250) prepared a diagram by plotting weight percentage of MgO against Al$_2$O$_3$/SiO$_2$ to distinguish tholeiites from alkali basalts. A similar diagram for the dolerites of the thesis area was prepared and it was found that the trend is parallel to the tholeiite trend suggesting that the parent magma is tholeiitic in composition (Fig. 35). The Niggli molecular values of the dolerites also match favourably with those of tholeiite.
The differentiation of the alkali basalts has been thought about for many years, but the idea of crystal fractionation of felsic and mafic components is discussed below.

**FIG. 34. SILICA-ALKALIES DIAGRAM**

**FIG. 35. Al₂O₃/SiO₂ - MgO DIAGRAM**
The differentiation of tholeiitic magma has been brought about by crystal fractionation. The trend of crystallization of felsic and mafic constituents is discussed below.

Plagioclase feldspars are the most important felsic constituent of the dolerites of the thesis area. On the basis of his experimental studies Bowen (1930) concluded that lime-soda feldspars crystallise early in the felsic sequence and have an extensive range. This corroborates with the evidence obtained of the microscopic studies of dolerites of the thesis area. Orthoclase and quartz are found to crystallise late in the sequence. The early separation of lime-soda feldspar has given rise to gradual increase in SiO₂, Na₂O and K₂O in the later members of the dolerites occurring around Chetput.

The following mafic constituents are recognized in the dolerite dykes of the area: Olivine, pigeonite, enstatite, augite, sub-calcic augite, bronzite, ferriferous pigeonite, ferriferous sub-calcic augite, ferro-augite, hornblende and biotite.
The early crystallisation of minerals rich in MgO has given rise to increase of FeO in the later members. As a consequence ortho- and clino-pyroxenes display iron enrichment in the later members of the dolerite dykes around Chetput.

The presence of picotite among the opaque ores in the fine-grained dolerites and of the titano-magnetite in the medium-grained dolerites is suggested by the low proportion of FeO and Fe$_2$O$_3$ in the early members and gradual increase of FeO, Fe$_2$O$_3$ and TiO$_2$ in the later members.

The presence of micro-pegmatite in the later members of the dolerite suggests the segregation of volatile rich phase in the end stage of differentiation. The presence of hornblende, biotite and micro-pegmatite in the later members suggests that the water content was high in the tholeiitic member. This probably explains the growth of relatively large euhedral and subhedral crystals of mineral constituents in the later members because the presence of volatiles would have reduced the viscosity of the tholeiitic magma thereby facilitating the growth of relatively large crystals.