Chapter III

PETROGRAPHY

Megascopic

The dyke rocks are either basaltic or doleritic. In the Neral Group there are 9 basaltic dykes and only two are doleritic. On the other hand in the Badlapur Group 17 are doleritic and only 2 are basaltic. The Karjat Group has 6 doleritic and 4 basaltic dykes.

Most of the basaltic rocks are conspicuously prophyritic being crowded with phenocrysts of plagioclase upto 2 cm. in length. Exceptions are Dykes Nos. 139 and 174 which are completely aphanitic. The doleritic dykes are usually fine to medium grained and equigranular but some like Dyke Nos. 124 and 160 are porphyritic with large phenocrysts of plagioclase. In Dyke No.127 and 129 which are normally medium grained doleritic there are patches showing a concentration of giant sized phenocrysts upto 10 cm. across. Similar concentration of phenocrysts in small patches only is also shown by Dyke Nos.121 and 124 but the phenocrysts are much smaller upto 5 cm. in Dyke No.124 and 2 cm. in Dyke No.121.
Microscopic

Under the microscope the dykes are seen to be composed of plagioclase, augite, olivine, iron ore and glass as primary constituents and palagonite, iddingsite, chlorophaeite and calcite as secondary minerals. In texture they range from fine grained basalts to coarse dolerites. With only minor differences the dykes as a group show fairly uniform characters.

Table I

Proportion of Minerals by Volume
(by Delessee-Rosiwaal Method)

<table>
<thead>
<tr>
<th>Dyke</th>
<th>Plagioclase</th>
<th>Pyroxene</th>
<th>Olivine</th>
<th>Iron Ore</th>
<th>Seco. Min.</th>
<th>Glass</th>
</tr>
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<tbody>
<tr>
<td>111</td>
<td>49</td>
<td>31</td>
<td>-</td>
<td>5</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>117</td>
<td>43</td>
<td>27</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>118</td>
<td>50</td>
<td>20</td>
<td>11</td>
<td>4</td>
<td>1.5</td>
<td>13.5</td>
</tr>
<tr>
<td>127</td>
<td>51</td>
<td>32</td>
<td>-</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>130</td>
<td>46</td>
<td>26</td>
<td>14</td>
<td>3</td>
<td>1.5</td>
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<td>137</td>
<td>39</td>
<td>18</td>
<td>30</td>
<td>3</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td>142</td>
<td>53</td>
<td>33</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
Textures and Microstructures

All basaltic dykes are porphyritic, though there is considerable variation in the size and number of phenocrysts and the grain size of the groundmass. Some dykes (e.g., Nos. 131 and 149) have a fine grained groundmass and contain a comparatively small number of small phenocrysts but usually phenocrysts are quite numerous and large. Most commonly phenocrysts are of plagioclase only as for example, in Dyke Nos. 108, 110, 113, 149, 173 etc., and dykes with phenocrysts of pyroxene and olivine are comparatively few.

Phenocrysts often cluster together giving glomeroporphyritic texture. There is also a marked tendency on part of smaller phenocrysts of pyroxene and olivine to cluster around large laths of plagioclase. This has also been seen to be common in dykes of other Deccan Trap areas and in some of the giant phenocryst basalts. In the case of the latter, aggregates of iddingsite are seen around large tablets of plagioclase even in handspecimens.

Intergranular and intersertal textures have sometimes been produced where interstices between elongated plagioclase laths, so arranged as to enclose
(60) Cluster of augite phenocrysts. Dyke No. 113. Ordinary light. 55 X.

(61) Cluster of plagioclase phenocrysts with a very large lath. Dyke No. 138. Crossed nicols. 25 X.


(63) Cluster of plagioclase phenocrysts. Dyke No. 108. Crossed nicols. 21 X.
Ophitic and Subophitic Textures

(64). Plagioclase laths completely enclosed in a large plate of augite. Dyke No. 129. Crossed nicols. 40 X.

(65) Plagioclase penetrating and completely enclosed in a large plate of augite. Dyke No. 129. Crossed nicols. 95 X.

(66) Large plate of augite penetrated by plagioclase and enclosing plagioclase and olivine. Dyke No. 113. Crossed nicols. 69 X.
triangular or polygonal spaces, have been occupied by granules of olivine and augite (Dyke Nos. 108, 110), or by glass and its alteration products (Dyke Nos. 137, 142).

The doleritic rocks especially the coarser ones show ophitic texture with laths of plagioclase completely enclosed in subhedral plates of augite, or more commonly subophitic texture with long laths of plagioclase partially penetrating pyroxene.

Some dykes (Nos. 123, 129, 147, 155) show grains of olivine completely enclosed in augite.

Variolites are seen in glass where fibrous crystals resulting by devitrification are arranged radially.

Though the dykes appear quite compact and free from gas cavities in hand specimens, a few minute amygdales were seen under the microscope. The amygdales are filled with palagonite or calcite and have a circular or irregular but always rounded outline.

As a rule marginal portions are finer grained, but Dyke No. 111 shows no diminution of grainsize at the margins. The margins of porphyritic dykes appear more conspicuously porphyritic because of the reduction
(67) Intergranular texture with olivine grains filling interspaces between plagioclase laths. Dyke No. 113. Crossed nicols. 57 X.

(68) Intersertal texture.
Dyke No. 138. Crossed nicols.
24 X.

(69) Flow texture with laths of plagioclase arranged along flow lines. Dyke No. 105.
Ordinary light. 63 X.
of calcite in the groundmass. The fine grained of some dykes (Nos. 105, 110, 113, 117) show transpyc texture with a parallel arrangement of similar plagioclase needles.

(70) **Secondary calcite in Dyke No. 111. Ordinary light. 42 X.**

Amygdale filled with calcite and palagonite. Dyke No. 111. Ordinary light. 49 X.

**Plagioclase.** Plagioclase is the most predominant constituent of all dykes, its proportion varying from 95% to 98%. It occurs in large and medium sized laths with a subophitic relationship with pyroxene in the doleritic rocks. In the basaltic rocks it occurs as phenocrysts and also as smaller laths and slender needles in the groundmass. A few small laths also occur in glass.

(71) **Amygdale filled with calcite and palagonite. Dyke No. 111. Ordinary light. 49 X.** 

... and altered but in some cases have corroded borders due to resorption. The outlines of some grains is very irregular due to very advanced resorption. Many laths show numerous irregular cracks and some show faint twin laminae and undulose extinction. Inclusions...
of grain size of the groundmass. The finer margins of some dykes (Nos. 105, 110, 113, 117) show trachytic texture with a parallel arrangement of slender plagioclase needles.

Usually the thicker dykes are coarse and the thinner ones finer. But Dyke No. 139 though 4 meters thick is quite fine grained, whereas Dyke No. 138 though only 60 cm. thick, is crowded with large phenocrysts of plagioclase.

Plagioclase - Plagioclase is the most predominant constituent of all dykes, its proportion varying from 39% to 53%. It occurs in large and medium sized laths with a subophitic relationship with pyroxene in the doleritic rocks. In the basaltic rocks it occurs as phenocrysts and also as smaller laths and slender needles in the groundmass. A few small laths also occur in glass.

The plagioclase is quite fresh and unaltered but in some cases the phenocrysts have corroded borders due to resorption. The outline of some grains is very irregular due to very advanced resorption. Many laths show numerous irregular cracks and some show bent twin lamellae and undulose extinction. Inclusions
(72) A Baveno twin. Dyke No. 105. Crossed nicols. 49 X.

(73) Plagioclase with inclusions of augite and iron ore along twin planes. Dyke No. 139. Ordinary light. 20 X.

(74) A phenocryst of plagioclase in Dyke No. 157. Crossed nicols. 24 X.
Plagioclase

(75) Zoned plagioclase. Dyke No. 108. Crossed nicols. 65 X.

(76) Plagioclase showing zoning and corroded borders. Dyke No. 139. Crossed nicols. 48 X.

(77) Plagioclase showing strain effects. Dyke No. 110. Crossed nicols. 46 X.
Plagioclase with Corroded Borders

(78) Dyke No. 110. 92 X.
Ordinary light.

(79) Dyke No. 124. 50 X.
Ordinary light.
Plagioclase with Corroded Borders

(30) Dyke No. 110. Ordinary light. 77 X.

(81) Dyke No. 110. Ordinary light. 88 X.
of dusty iron ore are very common, sometimes with a rude zonal arrangement, and small granules of pyroxene and olivine also occur as inclusions.

Between crossed nicols the characteristic polysynthetic twinning on albite, and complex albite carlsbad laws is seen. Sometimes fine strips of pericline twinning are also seen crossing the albite lamellae almost at right angles. A Baveno twin was noticed in Dyke No. 105.

Penetration and cruciform twins are present in majority of the dykes, particularly the coarser ones. The angle between the two individuals forming the cross is most commonly a right angle, but is variable. Zoning is shown by some phenocrysts, but it is always so feeble that it is not possible to determine the difference in composition between the core and the margin.

The composition of the plagioclase varies between An 55 and An 75, but the bulk of it falls between An 60 and An 70. No remarkable difference was noticed in the composition of the laths of the groundmass and the phenocrysts.
Cross Twins of Plagioclase

(82) Dyke No. 138. Crossed nicols. 27 X.

(83) Dyke No. 111. Crossed nicols. 105 X.

(84) Dyke No. 111. Crossed nicols. 94 X.

(85) Dyke No. 131. Crossed nicols. 82 X.
Groups of Cross Twins

(86) Dyke No. 129. Crossed nicols.
31 X.

(87) Dyke No. 129. Crossed nicols.
36 X.

(88) Dyke No. 129. Crossed nicols.
36 X.
### Table II

**Variation in Anorthite Content of Plagioclase**

<table>
<thead>
<tr>
<th>Dyke No.</th>
<th>Anorthite percent</th>
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</thead>
<tbody>
<tr>
<td>Karjat Group</td>
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<tr>
<td>105</td>
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<tr>
<td>117</td>
<td>63, 67, 68, 68, 70</td>
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<td>118</td>
<td>70, 75, 80, 75</td>
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<tr>
<td>121</td>
<td>59, 63, 61</td>
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<tr>
<td>Neral Group</td>
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<tr>
<td>108</td>
<td>53, 57, 55, 61</td>
</tr>
<tr>
<td>110</td>
<td>63, 67, 61, 65</td>
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</tr>
<tr>
<td>113</td>
<td>57, 60, 61, 55</td>
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<tr>
<td>Badalapur Group</td>
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</tr>
<tr>
<td>126</td>
<td>60, 58, 59, 63</td>
</tr>
<tr>
<td>127</td>
<td>57, 63, 58</td>
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<td>148</td>
<td>63, 61, 63, 58</td>
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<tr>
<td>155</td>
<td>53, 57, 60</td>
</tr>
</tbody>
</table>

*Pyroxene - Monoclinic pyroxene is present in all dykes, and is next to plagioclase in abundance. Its proportions varies from 18 to 33%.*
Pyroxene

(89) Euhedral phenocryst.
Dyke No. 108. Ordinary light. 58 x.

(90) Euhedral crystal in glass.
Dyke No. 111. Ordinary light. 70 x.

(91) Euhedral crystal showing twinning. Dyke No. 155.
Crossed nicols. 46 x.
Pyroxene

(92) Augite with bent cleavages.
Dyke No. 111. Ordinary light.
88 x.

(93) Pyroxene larger than plagioclase.
Dyke No. 142. Crossed nicols.
20 x.

(94) Large plates of augite showing
one set of cleavages. Dyke No. 155.
Ordinary light. 49 x.
In the dolerites it occurs as large allotriomorphic plates penetrated by plagioclase laths. It builds large phenocrysts in some basalts, but more commonly occurs as granules in groundmass. The phenocrysts are usually platy and subhedral and only occasionally an eight sided euhedral section is seen. The phenocrysts commonly cluster together giving glomeroporphyritic texture, and sometimes arrange themselves around plagioclase phenocrysts.

The pyroxene is generally pale brown or colourless and nonpleochroic. It has a high refractive index and rather low birefringence. Prismatic cleavage is well developed. In some dykes bent crystals with curved cleavage lines are seen. Twinning is common in some dykes. It is usually simple, orthopinacoidal.

Measurement of 2 V of 53 grains on the Universal stage using segments of R.I. 1.648 gave an average value of 46.5°, the maximum and minimum being 53° and 44° respectively. Average C\(\angle\) Z is 40°. The optical character of the pyroxene are thus similar to those of the clinopyroxenes occurring in the Deccan Trap basalts and designated by West (1952) as sub-calcic augite.
<table>
<thead>
<tr>
<th>Areal group</th>
<th>Dyke no.</th>
<th>2V (all positive)</th>
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<tr>
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<td>Neral</td>
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<td>113</td>
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<td>Badalapur</td>
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<td></td>
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<td></td>
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<td>151</td>
<td>47, 46, 45</td>
</tr>
<tr>
<td></td>
<td>155</td>
<td>46, 48</td>
</tr>
</tbody>
</table>
**Olivine** - Olivine is abundant in the group as a whole, but it is not present in all dykes. Dyke Nos. 121, 122 and 160 from the Karjat Group, 111 and 139 from the Neral Group, and 126, 127, 131, 142, 148, 149 and 151 from the Badlapur Group do not contain olivine. In the dykes that contain olivine its proportion varies from 7% to 30%.

Most of the olivine is quite fresh showing alteration only along cracks and margins. It usually occurs as rounded grains, but euhedral crystals with more or less corroded borders are also common. It is colourless and shows high relief. D.R. colours are very bright second order. Crystals show numerous irregular cracks along which alteration to palagonite or chlorophaeite has taken place. By complete alteration along cracks, some crystals show a network of veinlets filled with iron ore. Alteration in some crystals has started from the margins and in some cases only a core of fresh olivine survives. Occasionally complete alteration to iddingsite, delessite or palagonite is seen.

Determinations of 2 V on the Universal Stage with segments of R.I. 1.648 gave values from 76° to 88°, giving a variation in composition from 45% forsterite...
Olivine

(95) Fresh and idiomorphic phenocrysts. Dyke No. 137. Ordinary light. 24 X.

(96) Fresh phenocryst showing beginning of alteration along margins and cracks. Ordinary light. 31 X. Dyke No. 137.

(97) Same as No. 96. Dyke No. 137. Ordinary light. 29 X.
Olivine

(98) Olivine showing advanced alteration along cracks. Dyke No. 146. Ordinary light. 45 X.

(99) Phenocryst showing advanced alteration along margins and cracks. Dyke No. 108. Ordinary light. 28 X.

(100) Delessite, pseudomorphous after olivine. Dyke No. 108. Ordinary light. 29 X.
to 70% forsterite. Olivine of Dyke Nos. 108, 118 and 143 is more magnesian than the olivine usually found in the dykes.

Table IV

2 V of Olivine

<table>
<thead>
<tr>
<th>Areal Group</th>
<th>Dyke No.</th>
<th>2 V (All negative)</th>
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<td>Neral</td>
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<tr>
<td></td>
<td>113</td>
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<tr>
<td>Karjat</td>
<td>117</td>
<td>80, 80</td>
</tr>
<tr>
<td></td>
<td>118</td>
<td>82, 78, 87</td>
</tr>
</tbody>
</table>

Iron Ores - These are the most common accessory constituents of the dykes. Generally they occur as needles, rods, granules and dust, and as microlites and crystallites in the glass. Well developed plates are comparatively rare. Inclusions of dusty iron ore are frequently seen in plagioclase.
Iron Ores

(101) Large plates. Dyke No. 126. 30 X. Ordinary light.

(102) Triangular plates. Dyke No. 155. Ordinary light. 26 X.

(103) Needles showing a peculiar arrangement all around a lath of plagioclase. Dyke No. 108. Ordinary light. 85 X.
Glass - Glass is invariably present in all dykes including the coarsest. Its proportion varies considerably and bears some relation with the grainsize of the dyke. Only small amounts are present in the coarser dykes while the finer ones contain a considerably larger amount.

When perfectly fresh it is colourless or pale brown or yellowish brown. However, in most dykes much of the glass has altered to green or brown palagonite and chlorophaeite. The glass is generally isotropic, but at places contains cryptocrystalline material showing very low birefringence and a cross between crossed nicols. This appears to have been produced by devitrification. Microlites of iron ore and plagioclase and granules of olivine and pyroxene are enclosed in the glass. In dykes in which iron ore has failed to crystallise the glass is dark black and opaque.

The Secondary Minerals:

Palagonite is the commonest of the secondary constituents and occurs in all dykes as irregular interstitial patches replacing the glassy base from which it has resulted. It is commonly pale brown to
yellowish in colour, but the bright green variety, chlorophaeite, also occurs. Though usually formed by alteration of glass, patches pseudomorphous after olivine show that some of it has been formed by the alteration of olivine. It is isotropic for the most part, but portions of some patches are cryptocrystalline or microcrystalline.

Iddingsite occurs as irregular or rounded orange-red coloured plates pseudomorphous after olivine. Some plates show the characteristic crystal form of olivine. It is strongly pleochroic between orange and deep brownish red. Double refraction colours are third order, but are usually masked by the strong absorption. It has at places altered to green or brown palagonite.

Delessite occurs as an alteration product of olivine. It shows overlapping scales and is pleochroic between pale yellowish green and a deeper shade of green. Double refraction is low. It has at places altered to palagonite.

Calcite occurs as an infilling in the rare gas cavities in association with palagonite and chlorophaei
Rhombohedral cleavage is well developed and twinkling when rotated in polarised light is conspicuous. It shows high order D.R. colours and is uniaxial negative.

**Order of Crystallisation:**

The interrelationships between the primary constituents indicate that olivine was invariably the first mineral to crystallise, followed by plagioclase and pyroxene together and iron ore was the last to crystallise.

Though olivine is frequently seen enclosed in plagioclase and pyroxene, no mineral has ever been observed enclosed in olivine. It also shows well developed crystal form. It is clear from these observations that olivine crystallised out before the other minerals.

Plagioclase ophitically and subophitically enclosed in pyroxene is common, but pyroxene enclosed in plagioclase is also seen, though less frequently. Though plagioclase phenocrysts are usually larger than those of pyroxene, in some cases the latter are larger. Also, both minerals occur, both as phenocrysts and as needles and granules in the groundmass. All this indicates that the two minerals had prolonged and overlapping periods of crystallisation.
Occurrence of iron ore in well developed crystals is comparatively rare. In some dykes it has not crystallised at all and is confined to the glass which has become black and opaque. Though inclusions of iron ore are seen in plagioclase, the iron ore in such cases is only dusty and is never well crystallised. On the other hand iron ore is often found moulded on plagioclase laths or pyroxene grains. It would thus appear that the iron ores were the last to separate from the dyke magma.

References