CHAPTER - VIII

RHYOLITE

Rhyolitic rock is pink, brownish and grey in colour, fine grained, and porphyritic with the phenocrysts of tabular feldspar within a glassy groundmass. Flow bands in glass are found around the feldspar phenocrysts. Microscopically, the identified minerals include plagioclase and clinopyroxene (hedenbergite) as phenocrysts; whereas the groundmass is composed of altered and unaltered glass, spherulites, fine needles of plagioclase, sphene, epidote and iron ores.

DISTRIBUTION

Two different occurrences of rhyolitic rocks have been exposed in the present area. The major one is exposed in the eastern and northeastern parts of Devda village, whereas the other is of minor occurrence and located north of Sajanwala.

Rhyolitic rocks to the northeast and east of Devda village are exposed in the low lying parts of Alech hills covering an area of about 5 sq. miles (12.8 sq. km.) in the investigated area. The rock type is of both pink and grey coloured varieties and porphyritic. Some are remarkably flow banded with glass. The strike and dip of the same are measured as (1) N35°W/70° easterly, (2) N18°W/75° easterly, (3) N35°E/58° easterly, (4) N10°W/32° easterly, (5) N30°E/75° easterly and (6) N65°W/82° easterly, which indicate that the trend of flow layers is both northeasterly and northwesterly. The subvertical attitude of the flow layers is also noteworthy. This rhyolite occurrence of Devda area, appears to abut against the subhorizontal basaltic flow.

Rhyolite occurrence in the Sajanwala area is of smaller size, covering an area of less than one sq. mile (i.e., less than 2.5 sq. km). It is bounded by felsite, granophyre and basaltic stoped block along its north, west and eastern
parts respectively. The contact is sharp against the basalt whereas it is gradational with the felsite and granophyre. The rock type is mostly devitrified to form felsitic groundmass.

**MODE OF OCCURRENCE**

The extreme fine grained and glassy nature of the groundmass indicate that the rock type was almost extruded on the surface or intruded at a very shallow depth, in contrast to the slightly deeper emplacement of the granophyre and felsite. The rate of supercooling was extremely high in comparison to felsite. The felsitic nature of the Sajanwala type, appears to be due to devitrification of rhyolitic glass. The Devda rhyolite has no visible direct contact against the basalt in the western part; but it appears that the rhyolitic rocks having steeply inclined flow structure, have been intruded or extruded through the basaltic rock, and has also imparted thermal metamorphic effects to the latter.

**PETROGRAPHY**

In hand specimens, the Devda rhyolite is pink to brown in colour and porphyritic with the phenocrysts of tabular feldspar (maximum 5 sq. mm) of both altered and unaltered transparent varieties within very fine grained and brown coloured glassy groundmass; flow layers formed by glass are commonly found around feldspar phenocryst. Specimen from rhyolitic rock at Sajanwala, is commonly light grey in colour and porphyritic with the mega phenocrysts of feldspar within microcrystalline (devitrified) groundmass.

The thin section petrography of a few typical specimens collected from the different parts of the rhyolite occurrence is described here.

**DEVDA AREA**

Sp. No. 11/14.2 : From the western part of the rhyolite occurrence.

Microscopically, the rock is porphyritic with phenocrysts of plagioclase
within very fine grained, glassy groundmass.

Plagioclase phenocrysts occur as tabular and patchy grains with little albitic replacement and with indistinct albite type twinning. Inclusions of iron ores in the phenocrysts may have been derived from glass inclusions.

The groundmass is very fine grained and composed of glass (deep brown and green coloured) and fine anhedral quartz grains in small amount. The groundmass is characterised by faint flow layers as defined by fine crystallites. The deep brown colour of the groundmass is due to high iron content in the glass. Greenish patches are of altered glass.

Sp. No. 4/14.2: From the central part.

Microscopically, the rock appears porphyritic with phenocrysts of plagioclase and clinopyroxene within a very fine grained groundmass.

Plagioclase phenocrysts are common in the form of euhedral tabular to fine laths; some grains are resorbed and show imperfect polysynthetic twinning (Fig. 43). In a grain, two sets of rhombically crossed twinning (Fig. 44) have been observed. Inclusions of clinopyroxene, iron ores and chlorite are found within plagioclase phenocrysts. Chlorite inclusion is a probable pseudomorph after olivine.

Clinopyroxene (hedenbergite) is common as phenocryst, occurring as subhedral prisms of medium sizes, which are pale green in colour with weak but distinct pleochroism.

Groundmass is very fine grained and composed dominantly of glass, in association with fine spherulites, quartz, epidote, sphene and iron ores. Iron ores with their spongy and skeletal texture are well preserved. Flow structure formed by glass and crystallites swerves around plagioclase phenocrysts (Figs. 45, 46). Thin veins of quartz and limonitic materials form from devitrified and
Fig. 43. Photomicrograph showing plagioclase phenocryst with its euhedral and tabular form and having polysynthetic twinning. Crossed nicols, x 82.

Fig. 44. Photomicrograph showing plagioclase phenocryst with two sets of twinning. The phenocryst shows inclusion of clinopyroxene. Crossed nicols, x 82.

Fig. 45. Photomicrograph showing flow structure formed by glass and crystallites, swerving around plagioclase phenocrysts (white, squarish). Ordinary light, x 28.
leached glass in the groundmass, the veins have cross-cutting relation with plagioclase phenocrysts.

Iron ores are titanomagnetite forming numerous dusty or very fine discrete octahedral grains. A few are large and have poliklitic intergrowths with silicates (pyroxene). The grains are mostly maghemitised.

**Sp. No. 2A/15.5.75**: From the central part of the rhyolite occurrence.

In thin section the rock is porphyritic with plagioclase phenocrysts lying in a very fine grained groundmass.

Plagioclase phenocrysts are common, coarse to medium in size, having tabular to subhedral prismatic form; they are slightly zoned with imperfect albite type twinning, and show inclusions of iron ores and altered glass.

Groundmass is very fine grained composed of glass and iddingsite pseudomorphous after olivine which occurs as microphenocryst. Iron ores occur in the groundmass as fine microlites as well as coarse and euhedral grains. Fine anhedral grains of quartz occur in minor amount. Rhyolitic texture is well developed and there is a lack of devitrification.

**Sp. No. 73/15.1.70**: From the southern part of the rhyolite occurrence.

Microscopically, the rock is porphyritic with phenocrysts of plagioclase and clinopyroxene lying in a very fine grained glassy groundmass.

Plagioclase phenocrysts commonly occur as large tabular to subhedral prisms, mostly altered to sericite and minor albite, they are cleaved and highly fractured.

A few basal sections of clinopyroxene are of medium sizes and occur as phenocrysts.
Groundmass is very fine grained, brown coloured and consists mainly of ferruginous glassy materials in places devitrified into quartz grains, thin laths of plagioclase and altered green glass and subhedral to anhedral grains of iron ores. Patches representing fragments of basalt with relict plagioclase laths have been observed (Fig. 47). Pseudomorphs after fayalitic olivine have been observed.

SAJANWALA AREA
Sp. No. 4/13.5.75 : From the Sajanwala-Modhpur metalled road side.

The thin section study shows that the rock is porphyritic with phenocrysts of plagioclase in a very fine grained felsitic to rhyolitic groundmass.

One tabular, zoned, untwinned and altered plagioclase phenocryst has been observed.

Fine grained groundmass is composed of fine intergrowths of quartz and alkali feldspar, brown patches of devitrified glass. Thin vein like form of quartz is common in the groundmass.

Clinopyroxene with a deep green colour occurs as fine anhedral granules and needles. Zoning in the finer grains is common.

Iron ores are granular to equidimensional and occur in places as rim around the pyroxene. Iron ores have been identified as titanomagnetite, which are of small octahedral to fine dust like forms, at places show poikilitic intergrowth with silicates. Maghemisation in titanomagnetite has been observed. A few small and interstitial ilmenite laths have been traced. Sulphides are rarely represented by dot-like grains of chalcopyrite.

Sp. No. 18/15.2 :
Microscopically, the rock is porphyritic with phenocrysts of plagioclase and clinopyroxene in a rhyolitic to felsitic groundmass.
Plagioclase phenocrysts are large but with resorbed borders and in places altered to sericite.

Groundmass is very fine grained and felsitic with very fine grained intergrowths (devitrified) of quartz and alkali feldspar (Fig. 48). Patches of glass with flow layers as defined by fine crystallites are preserved.

Quartz grains in free forms, occur both as elongated high temperature forms and as thin veins.

Alkaline clinopyroxenes are deep green in colour with distinct pleochroism. Subhedral to euhedral grains of iron ores, at places enclosed in pyroxene grains, are suggestive of their formation earlier than the pyroxene.

MODAL DATA

The modal compositions (volume percent) of constituent minerals in rhyolitic rocks, are shown in the following Table 20. The rhyolites of Devda area appear to be more glassy than those of Sajanwala.

TABLE 20
Modal Data of Constituent Minerals in Rhyolite

<table>
<thead>
<tr>
<th>Slide No.</th>
<th>Plagioclase</th>
<th>Very fine grained quartz and alkali feldspar intergrowths (devitrified glass)</th>
<th>Glass</th>
<th>Free quartz</th>
<th>Clinopyroxene</th>
<th>Iron ores &amp; other accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/14.2 Devda</td>
<td>9.4</td>
<td>Nil</td>
<td>76.4</td>
<td>12.4</td>
<td>Nil</td>
<td>1.8</td>
</tr>
<tr>
<td>4/14.2 Devda</td>
<td>14.1</td>
<td>Nil</td>
<td>74.5</td>
<td>4.9</td>
<td>1.6</td>
<td>4.9</td>
</tr>
<tr>
<td>2A/15.5.75 Devda</td>
<td>3.9</td>
<td>Nil</td>
<td>92.2</td>
<td>2.4</td>
<td>Nil</td>
<td>1.5</td>
</tr>
<tr>
<td>73/15.1.70 Devda</td>
<td>11.3</td>
<td>Nil</td>
<td>76.9</td>
<td>1.9</td>
<td>0.6</td>
<td>9.3</td>
</tr>
<tr>
<td>4/13.5.75 Sajanwala</td>
<td>0.1</td>
<td>64.8</td>
<td>14.5</td>
<td>10.1</td>
<td>8.2</td>
<td>2.3</td>
</tr>
<tr>
<td>18/15.2 Sajanwala</td>
<td>2.9</td>
<td>66.0</td>
<td>12.5</td>
<td>12.2</td>
<td>0.8</td>
<td>5.6</td>
</tr>
</tbody>
</table>
Photomicrograph showing flow structure formed by glass and crystallites; a thin quartz vein is also seen. Ordinary light, x 28.

Fig. 46.

Photomicrograph showing altered and angular xenolithic patch (black) of basalt with relict plagioclase laths (clear). Crossed nicols, x 82.

Fig. 47.

Photomicrograph showing devitrified felsitic groundmass. Crossed nicols, x 23.

Fig. 48.
The chemical analysis and norm (C.I.P.W) of a rhyolitic rock, collected from Devda area is shown in the following Table 21.

**TABLE 21**

Chemical Analysis and Norm of Rhyolite

<table>
<thead>
<tr>
<th>Chemical analysis</th>
<th>Normative C.I.P.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$ = 69.12</td>
<td>Quartz = 20.32</td>
</tr>
<tr>
<td>Al$_2$O$_3$ = 12.50</td>
<td>Orthoclase = 27.80</td>
</tr>
<tr>
<td>TiO$_2$ = 0.45</td>
<td>Albite = 37.73</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ = 3.99</td>
<td>Anorthite = 0.28</td>
</tr>
<tr>
<td>FeO = 1.72</td>
<td>Diopside = 5.76</td>
</tr>
<tr>
<td>MnO = 0.02</td>
<td>Enstatite = 0.38</td>
</tr>
<tr>
<td>CaO = 1.56</td>
<td>Ferrosilite = 3.38</td>
</tr>
<tr>
<td>MgO = 0.28</td>
<td>Magnetite = 1.69</td>
</tr>
<tr>
<td>Na$_2$O = 4.47</td>
<td>Ilmenite = 0.91</td>
</tr>
<tr>
<td>K$_2$O = 4.70</td>
<td>Apatite = 0.34</td>
</tr>
<tr>
<td>FeO$_5$ = 0.154</td>
<td></td>
</tr>
<tr>
<td>H$_2$O$^+$ = 0.12</td>
<td></td>
</tr>
<tr>
<td>H$_2$O$^-$ = 0.70</td>
<td></td>
</tr>
</tbody>
</table>

Total = 99.78 Analyst - B. P. Gupta.

The salient features from the chemical analysis and normative data are summarised below.

(1) the normative quartz, orthoclase and (albite + anorthite), recalculated to 100, as 23.6, 32.3 and 44.1, indicate the rhyolite as equivalent to adamellite (quartz-
(2) the normative quartz, orthoclase and albite recalculated to 100, as 23.7, 32.4 and 43.9 have shown its position near the minima of experimental KAlSi$_3$O$_8$ - NaAlSi$_2$O$_8$ - SiO$_2$ - H$_2$O system of Tuttle and Bowen (1958).

(3) the differentiation index has been calculated as 86.13 percent, which indicates it as a felsic differentiates (Poldervaart, 1958).

(4) the oxidation ratio of this hedenbergite-bearing rhyolite has been calculated as 66.94, which is comparable to the alkali pyroxene-bearing granophyre with high oxidation ratio of 78 (De and Bhattacharya, 1971).

(5) the molecular proportions of soda and potash slightly exceed that of alumina and hence it shows a slightly peralkaline nature.

(6) the lime and magnesia content is low and this low magnesia content is shown by the occurrence of hedenbergitic pyroxene.

(7) the soda and potash values are comparatively higher than the other analysed samples of acid rocks; there is a slight excess of potash over soda.

SUMMARISED MINERALOGY

Plagioclase

Plagioclase phenocrysts commonly occur in the form of tabular euhedral to subhedral prisms. The proportions of plagioclase vary from 0.1 to 14.1 percent; but in Sajanwala rock, it does not exceed 2.9 percent. Resorption of the grains is evident by corroded edges; a small amount of patchy albitic replacement has been observed. The albitic replacement in feldspar indicates a hydrothermal modification by a solution of albite-acmite composition (Martin, 1969). Slightly zoned grains of normal type have also been observed. Polysynthetic twinning of albite type has been observed. Inclusions of clinopyroxene, iron ores and chlorite (possibly...
pseudomorphous after olivine) are common. The inclusions may be derived from glass by devitrification. Fracturing in the phenocrysts has also been noted. Very fine laths of plagioclase, possibly as devitrified products after glass are common.

Clinopyroxene

Clinopyroxene grains are common in the form of subhedral prismatic phenocrysts to fine anhedral granular forms in the groundmass. A few thin needle-like pyroxene are devitrified forms after glass. The phenocrysts are mostly of medium size. In some cases the fine granular pyroxene grains show zoning and are mostly associated with iron ores; the straight and sharp contacts with the iron ores in granular forms, indicate their simultaneous formation during the devitrification of primary glass in the groundmass. The clinopyroxene contents vary from 0.6 to 8.2 percent; but in Devda rhyolite it does not exceed 1.6 percent.

The following table shows the optical properties of clinopyroxene constituting the phenocrysts and groundmass of rhyolite.

**TABLE 22**

Clinopyroxene in Rhyolite

<table>
<thead>
<tr>
<th>Specimen No. and Location</th>
<th>Shape, colour and pleochroism</th>
<th>$2V_\text{z}$</th>
<th>$N_\text{Y}$</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/14.2 Devda</td>
<td>Phenocryst Stumpy prisms; sharply pleochroic. $Y =$ pale yellowish green $Z =$ deep yellowish green</td>
<td>59°</td>
<td>1.727 $\pm$ 0.003</td>
<td>Ca$<em>{47.5}$ Mg$</em>{7.5}$ Fe$_{45}$ (Hedenbergite)</td>
</tr>
<tr>
<td>18/15.2 Sajanwala</td>
<td>Groundmass Anhedral patchy, deep bright green with weak pleochroism and studded with iron ores.</td>
<td>68°</td>
<td>1.737 $\pm$ 0.002</td>
<td>(Ca Mg Fe$^{++}$)$<em>{82}$ (Na Fe$^{++}$)$</em>{18}$ (Aegirine-augite)</td>
</tr>
</tbody>
</table>
Glass

Glass is well preserved in the Devda rhyolite in comparison to that of Sajanwala rhyolite. In the Devda rhyolite, its modal proportions vary from 76.4 to 92.2 percent whereas in the Sajanwala rhyolite its amount reaches a maximum of 14.5 percent. Deep brown colour of the glass is probably due to its comparatively high iron content. Devitrified patches are composed of quartz, pyroxene, iron ores, plagioclase (thin needles) and chlorite.

Quartz and alkali feldspar

Felsitic intergrowth of quartz and alkali feldspar, is formed by the devitrification of original glass. Its proportion in the Sajanwala rhyolite reaches a maximum of 66.0 percent. Free quartz, grains of which are also product of devitrification, are fine anhedral and thin needle-like in forms. The devitrified spherulites formed from glass have also been traced.

Iron ores

The modal proportions of iron ores vary from 1.8 to 7.9 percent and occur as anhedral granular forms, mostly in association with pyroxene granules. Iron ores may also occur in fine needle-like form to coarse euhedral and subhedral grains.

Iron ores have been identified under the ore microscope mostly as titanomagnetite, which vary from dust like to very fine octahedral forms. A few grains show, at places, poikilitic intergrowths with silicates. Maghemitisation in titanomagnetite has also been noticed. A few fine and interstitial ilmenite laths have been observed. Sulphides are rarely represented by dot-like specks of chalcopyrite.

Other accessories

Other accessories in the groundmass of rhyolite include altered and brown coloured flaky chlorite (pseudomorphous after olivine microphenocryst), and
granular epidote and sphene in traces. A possible basaltic fragment with relict intergranular texture has been observed as a xenolith.

**TEXTURE**

The texture of Devjada rhyolite is fine grained, glassy and porphyritic with phenocrysts of plagioclase and clinopyroxene. The flow layers are typically formed by glassy bands and fine crystallites which swerve around plagioclase and pyroxene phenocrysts.

The rhyolite of Sajanwala area is rather felsitic than rhyolitic; it is composed of very fine intergrowths of quartz and alkali feldspar which are devitrification products from primary glass.

**PETROGRAPHIC SIGNIFICANCE**

Very fine grained and glassy nature of rhyolite indicate that this rock was extruded on the surface or intruded at shallower depths than that of granophyres and felsites. The rate of supercooling was extremely high in comparison to felsite. The spherulitic and microcrystalline patches within the glassy groundmass, appear to be due to devitrification. The flow structures in the glassy groundmass of rhyolite, defined by fine crystallites, indicate highly viscous nature of rhyolitic magma, which is also evident by its low water content \( (\text{H}_2\text{O}^+ = 0.12) \) in the analysed rock (in Table 21).

Spherulitic devitrification is a post emplacement process which has affected many rhyolitic lavas of Taupo region (Ewart, 1971). The most significant effect in the spherulitic devitrification is the progressive enrichment of both the bulk spherulite and coexisting residual glass in potash with increasing spherulite development. Ewart (1971) also stated that this post-eruptive alkali fractionation process during spherulite development is superimposed on the pre-eruptive phenocryst-liquid fractionation.
The microcrystalline patches in the groundmass are common, only in the most advanced stages of spherulite-type devitrification (Ewart, 1971). The microcrystalline areas with quartz and alkali feldspar are interpreted as representing the original glass, which underwent subsequent devitrification after the completion of earlier spherulite development.

The mineralogical and petrochemical evidences indicate the rock as a slightly peralkaline rhyolite, which may be the volcanic equivalent of peralkaline granite. That peralkaline type of magmatism can be related to the epirogenic doming or rifting of the continental crust (Vine, 1970).