Seventeen (17) representative rock samples were selected for chemical analysis. While selecting the samples, petrographic observations and field relationships of the rock types are made use of. The methods employed for the determination of the major elements are already briefly discussed in chapter I. Major elemental distributions of 17 alkaline rocks (Table XII) are studied and various petrochemical calculations are done. A few diagramatic representations are prepared to delineate the petrochemical behaviour and nature of parental source of the rocks of the investigated area. This practice of genetic interpretations from the chemical analyses of the rocks and their chemical affinities has been in use since 19th century. Subsequent workers of the present century have found it more advantageous to recalculate the weight percentages of the major chemical constituents obtained by chemical analyses into a set of standard normative minerals or molecules for purpose of comparison and interpretations. In this respect a few notable contributions are cited below:

CIPW norms are computed from the analyses and given in the Table (XIII). The computed values are made use of in preparing a few graphical representations.

It can be referred herewith that the Sung Valley plutonic complex is dominantly constituted by Serpentinite (Peridotite) at the central part of the complex and is surrounded by pyroxinite, the latter is profusely intruded by discordant and concordant veins and bodies of carbonatite, uncomphagrite and magnetite-apatite rocks. Fenite is another associated rock observed at the contact between the country rock and the plutonic complex. Such association has been described genetically by Le Bas (1989) in a very concise way. The chemical analyses (Table XII), petrographic study of the rocks also indicate that they are alkaline to subalkaline in nature with wide range of silica content (39% to 66%). The decreasing order of basicity and textural differentiation mark the existence of five distinct stages of evolution of the rocks, viz. (1) the earliest ultramafic stage, mainly clino and orthopyroxene rich rocks, (2) melilite-pyroxene rocks, (3) iholite type of rocks, (4) nepheline syenite and (5) carbonatites (see also Chattopadhyay and Hashimi, 1984). These five lithounits are at per with the three distinct lithounits namely Serpentinite - Pyroxenite - carbonatite established from other alkaline complexes elsewhere. Phlogopitization associated with carbonatite also suggest the late stage development process with decreasing order of basicity of the parental magma. Association of such lithounits is one of the few occurrences reported so far from north eastern part of
the Peninsular India.

The alkaline and subalkaline nature of the Sung Valley Complex become further evident from the presence of nepheline both in normative analyses and petrography. Steady rise of total alkali (Na$_2$O + K$_2$O) from serpentine to nepheline syenite is a clear indicative of differentiation in the magmatic environment (Figs. 37, 40, 41). There is a remarkable decrease of total iron and MgO from serpentinite (Peridotite) through pyroxinite to syenite rocks. This decreasing trend of basicity may be due to fractionation of mafic silicate melt to produce peridotite and pyroxenite at the earlier stages of crystallisation.

Alkaline plutonic facies type of rocks prevalent in the west coast of Indian Peninsular and along the Narmada Valley belt (Biswas and Desh Pande, 1973), Cretaceous Monteregian Hills of igneous province of South-western Quebec, Canada (Eby, 1987) have petrochemical and petrographical similarity with the alkaline rocks occurring in the area of the present study. Different Marker's diagrams show that the SiO$_2$ content of the rocks varies from 39 to 66%. Similarly K$_2$O + Na$_2$O also varies from 1 to 18%. The total alkali increases with increase of SiO$_2$ and the increase of SiO$_2$ is accompanied by the impoverishment of CaO, MgO, TiO$_2$ and total iron (Figs. 37, 40). The alkali and subalkaline nature of the rocks of the Sung Valley plutonic complex is reflected through the diagrams38-42.

Alkalinity of pyroxinite is indicated by the presence of
acmite, leucite and nepheline in their normative analyses (Table XIII). There is a minor elemental variation from coarse grained pyroxinite to medium to fine grained pyroxinite which may be due to potash metasomatism. Normative hypersthene and olivine are the two diagnostic minerals of peridotite which suggest the unsaturated nature of the rock. Similarly, analytical results of carbonatite indicate higher amount of CaO and CO\textsubscript{2} resulting the development of calcite which may be referred to as sovitic nature. The sovitic rocks are again characterised by higher P\textsubscript{2}O\textsubscript{5} which is a clear indicative of apatitic sovite. Ijolites show comparatively wide range of composition but SiO\textsubscript{2} range is similar to that of peridotite (see No. 15 & 16 of Table XII).

Fenites related to pyroxinites are only compared here chemically the former is enriched in SiO\textsubscript{2}, Na\textsubscript{2}O, K\textsubscript{2}O Al\textsubscript{2}O\textsubscript{3} while the latter type is characterised by higher content of total iron, MgO and CaO.

The serpentinite rocks are chemically similar to the average of (see no 18) but there is a slight variation in total iron content which is lower in case of cited averages. Similarly H\textsubscript{2}O content of the rocks of the present area is higher than the compared averages. Such as variations as seen in other rock types also.

There is a broad overall similarity in chemical and mineralogical compositions of the carbonatites and ijolites of the present area with the alkaline rocks occurring with the Deccan
Traps at Murud-Janjira area of Maharastra (Sethna, S.F. et al. (1991) and in the light of the conclusions drawn by the writers on the probable source of the Deccan Trap alkaline rocks it can be inferred that the alkaline rocks (ijolites) of the present area were genetically related to the associated carbonatite.

Plots of the normative feldspar in the Or-Ab-An diagram (Muller and Saxena, 1977) show that the ternary feldspar of the alkaline rocks are fall on the 650°C temperature range (Fig. 44).

The following general observations as well as chemical variations of the different members of the complex can be made:

1. \( \text{Na}_2\text{O} \) is proportionately more than \( \text{K}_2\text{O} \) in the alkaline rocks (Fig. 42).
2. Higher content of \( \text{P}_2\text{O}_5 \).
3. Relatively more \( \text{MgO} \) and total iron.
4. Normative nepheline constituents up to 7.6%.
5. In the syenite rocks the total alkali is less than \( \text{Al}_2\text{O}_3 \).
6. There is a general increase of \( \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{Al}_2\text{O}_3 \) and \( \text{SiO}_2 \) and decrease of \( \text{CaO}, \text{MgO} \) and total iron from pyroxinite to fenite (Fig. 37). This comparison is not applicable to the fenite zone developed in the quartzites.
7. Harker's plots of other oxides against \( \text{SiO}_2 \) show a steady decrease of \( \text{CaO}, \text{MgO}, \) total iron while \( \text{Al}_2\text{O}_3, \text{Na}_2\text{O}, \)
$K_2O$ show initial increasing habit followed by gradual decrease (Fig. 37).

These features are indicative of mineral controlled magmatic evolution for the parental liquid of the suite (Krishnamurthy, 1985). The diagrams (40, 45) can be used to show alkaline and subalkaline nature of the rocks of the present area. Olivine associated with magnetite developed at the earliest stage of crystallisation and resulted in peridotite. It suffers from transformation and as an end product, serpentinite was formed in the central part of the area under study. Fall in the context of CaO, MgO and SiO$_2$ was due to large scale precipitation of clinopyroxene and the residual liquid magma become ijolitic. After further precipitation and separation of nepheline together with aegirine augite and apatite, the residual liquid become enriched in alkali and become syenitic. Mineralogical behaviour and their modal composition also suggest similar continuous chemical variation in the composition of the rocks of the area.

From the above observations it can be suggested that the higher $H_2O$ content may have some impact on the magma which reduces the viscosity and thus facilitates the rapid crystallisation and settling of crystals leading to the development of rocks of alkaline affinity. The source of the rocks of the present area was possible belongs to the low velocity zone produced by partial melting of the lower part of the lithosphere in the presence of $H_2O$ molecules and rose to the earth surface along the NNW-SSE and NE-SW trending tectonic lineaments.
### TABLE - XII

<table>
<thead>
<tr>
<th>Nepheline Syenite</th>
<th>Leucite</th>
<th>Pyroxenite</th>
<th>Nepheline-Peroxidite</th>
<th>Peridotite</th>
<th>Carbonatite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oxides</strong></td>
<td><strong>SiO₂</strong></td>
<td><strong>Al₂O₃</strong></td>
<td><strong>Fe₂O₃</strong></td>
<td><strong>CaO</strong></td>
<td><strong>Na₂O</strong></td>
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<tr>
<td><strong>SL.NO. 6</strong></td>
<td>Average of 80 samples of Nepheline Syenite after Nockolds (1954).</td>
<td></td>
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<td></td>
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<tr>
<td><strong>SL.NO. 10</strong></td>
<td>Average of samples of Iolite after Brogger (1921).</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>SL.NO. 14</strong></td>
<td>Average of pyroxenite of Srivastava (1989).</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>SL.NO. 18</strong></td>
<td>Average of 23 samples of Nockolds (1954).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- SL.NO. 10: Average of samples of Iolite after Brogger (1921).
FIGURE

37. Silica variation diagrams of the rocks of the Sung Valley alkaline complex.
FIGURE

38. Na$_2$O-(FeO+MnO) diagram showing the plots of the Sung Valley alkaline complex.

39. CaO-(K$_2$O+Na$_2$O) diagram showing the plots of the different rock types of the Sung Valley alkaline complex.
Fig. 38

Fig. 39

INDEX
- Nepheline Syenite
- Iolite
- Pyroxinite
- Peridotite
- Fenite

Na₂O

FeO + MnO

K₂O + Na₂O

CaO
FIGURE

40. Plot of the Al$_2$O$_3$ verses silica (Wt %) of the rocks of the Sung Valley alkaline complex. The alkaline and sub-alkaline fields are shown in the diagram.

41. Na$_2$O-(K$_2$O-Na$_2$O) plots of the rocks of the Sung Valley alkaline complex.
FIGURE

42. $K_2O$ versus $Na_2O$ (wt %) diagram for the alkaline and sub-alkaline rocks of the Sung Valley plutonic complex of the studied area.

43. $CaO-(MgO + FeO) - (Na_2O + K_2O)$ diagram showing the fields of alkaline rocks where plots of the present rock types are shown.
44. Or-Ab-An diagram showing the plots of the alkaline rocks of the Sung Valley area.

45. Ol-Di-Hyper( normative) diagram after Chayes (1965) showing alkaline and sub-alkaline fields. Rocks are plotted accordingly.
**Fig.-44**

**Fig.-45**

**INDEX**
- x Nepheline Syenite
- o Iolite
- • Pyroxinite
- □ Peridotite
- + Fenite

Sub-alkaline

Alkaline