CONCLUSIONS

On the basis of (i) chemical and normative criteria, (ii) calculation of different indices, (iii) plots of various binary and ternary variation diagrams for both major and trace elements and (iv) Sr isotopic ratio data, the following conclusions may be drawn.

1) There are both tholeiitic and alkali olivine basalts in the Mount Girnar area. It may be relevant to point out here that at depths corresponding to pressures of about 8 kb, the thermal divide between the tholeiitic and alkali olivine basalts does not appear to exist and the two types of basalts can inter-change mutually (Yoder and Tilley, 1962, Coombs, 1963). Both from major element and trace element abundances, and from the element ratios, these basalts are found to be nearer to oceanic island basalts and are broadly different from continental basalts in general.

2) The magnitude of concentration of elements K, Rb, Cs, REE, Th, U and Pb and Rb/Sr ratios and Sr isotopic data etc., supports the oceanic ridge association of Mount Girnar, which is consistent with seismic studies and magnetic anomaly patterns (McKensie and Solater 1971, Vogt and Conolly 1971, Laughton et al 1973). This in
effect means that Mount Girnar may be a continental analogue of Iceland and may be related to the Mid-Indian oceanic ridge (75 m.y. B.P.) in the same manner as the Reykjanes ridge is related to Iceland today. Girnar basalts show slightly higher concentration of large incompatible elements compared to the Indian Ocean ridge basalts. Similar increase towards Iceland from Reykjanes ridge has been reported by Schilling (1973).

Thus the geographic position of Deccan basalts in Peninsular India may not be an accident but may be a consequence of the fact that the ridge joins Peninsular India near the Gulf of Cambay with which are connected (i) the E-W trending Narmada fault (rift) and its extension along the southern parts of Saurashtra Peninsula and (ii) the NNW-SSW trending deep faults flanking Cambay basin and the (iii) postulated Y-shaped rift in Maharashtra.

Plutonic Suite

1) The parental magma of the plutonic suite is of alkali olivine basalt composition.

2) The differentiation trends of the plutonic suite of Girnar igneous complex are comparable to the differentiation trends in respect of the alkali rock series of Gough island, Hawaiian islands and Scottish Highlands.

3) The trace element and Sr isotopic ratio data on lamprophyres suggest that they may not be of hybrid origin.
They probably represent a different lineage of desucent from the parent magma (after the formation of olivine gabbro) leading to the formation of syenites and nepheline syenites with high tantalum content.

4) There are both palingenetic/assimilational (<10 ppm Ta) and juvenile (>10 ppm Ta) varieties of syenites and nepheline syenites in the area.

5) The rhyolite porphyry in the area may be genetically related to the tholeiitic basalt magma, and there is evidence to indicate that crustal contamination may have been involved in its genesis.

**Schematic diagram of probable phases of volcanism and differentiation trends of plutonic suite**

**Plutonic suite**

<table>
<thead>
<tr>
<th>Phase IV</th>
<th>Acid intrusives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase III</td>
<td>Alkali olivine Crystallisation Olivine-gabbro (Nepheline normative)</td>
</tr>
<tr>
<td></td>
<td>basalt magma</td>
</tr>
</tbody>
</table>

- Palingenetic/assimilational syenites and nepheline syenites (low in Ta)
- Juvenile syenites and nepheline syenites (high in Ta)

**Flows**

<table>
<thead>
<tr>
<th>Phase II</th>
<th>Alkali olivine Alkali olivine basalt basalt magma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Tholeiitic Tholeiitic Differen- ? Rhyolite basalt magma basalt porphyry and crustal contamination</td>
</tr>
</tbody>
</table>
Neither the palaeomagnetic data nor the K-Ar age data available for Girnar have enough resolution to indicate unequivocally the time lag between the lavas and the plutonic suite.

Despite their apparently monotonous tholeiitic nature, there exist marked inhomogeneities in the Deccan Traps as indicated by sharp variations in K, Rb, Sr contents and K/Rb, Rb/Sr and $^{87}Sr/^{86}Sr$ ratios (Kurasawa, in preparation, and present study). These variations could have arisen by any combination of the following factors: (i) Degree of inhomogeneity in the mantle source material, as manifested by variations (say) in the phlogopite content, (ii) period of residence of the magma (if any) in the crust before extrusion, (iii) degree of crustal contamination and (iv) degree of magmatic differentiation. Geochemical evidence generally favours factor (i) in the case of most of the Deccan Traps basalts, though other factors are not ruled out. Since both tholeiitic and alkali olivine basalts occur in Girnar, and since palaeomagnetic data do not indicate that India drifted measurably between the emplacement of flows and plutonic suite, mantle inhomogeneity may not have played any significant role in regard to the genesis of Girnar basalts. Both crustal contamination and magmatic differentiation played an
Important part in the genesis of pegmatite acid and alkali members of the Girnar Complex.

Economic implications of the present study

Some of the nepheline syenites of Mount Girnar Complex have high tantalum content and the microsyenite (B55) of the area has very high Ta content (920 ppm), which is among the highest values reported in the world for syenites. Determination of tantalum in different fractions of this sample after heavy media and isodynamic separation indicated that the tantalum mineral is concentrated mainly in heavy fraction (sp. gr. ~4.0). The mineralogical and electron probe studies confirm that the mineral is pyrochlore.

Tantalum has important applications in electronics, defence and space technology. At present tantalum in our country is being obtained from the niobo-tantalates occurring in the pegmatites in Andhra Pradesh, Bihar and Rajasthan. Though the economic concentration of tantalum in nepheline syenites is well known elsewhere in the world (Ginsburg et al, 1972), this is the first report in India of a potential, low grade ore body (for Ta) in the nepheline syenites of India (internationally accepted cut-off grade for the economic exploitation of Ta is 500 ppm).