## APPENDIX - I

**BRIEF PETROGRAPHIC DESCRIPTION OF THE SAGAR SAMPLES USED FOR CHEMICAL ANALYSIS**

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>FLOW NO.</th>
<th>PETROGRAPHIC DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z/38</td>
<td>9</td>
<td>Same as Z/38. Plagioclase composition 52-54% An.</td>
</tr>
<tr>
<td>Z/34</td>
<td>9</td>
<td>Slightly coarser than Z/38 and Z/39.</td>
</tr>
<tr>
<td>Z/72</td>
<td>8</td>
<td>Fine grained basalt very similar to flow 9 above. Average plagioclase composition 60% An. 2 V's of pyroxenes ranging from 48 to 53%.</td>
</tr>
<tr>
<td>Z/71</td>
<td>8</td>
<td>Slightly coarser than Z/72 all properties similar to above.</td>
</tr>
<tr>
<td>Z/63</td>
<td>8</td>
<td>Same as above.</td>
</tr>
<tr>
<td>Z/62</td>
<td>7</td>
<td>Fine grained altered basalt.</td>
</tr>
<tr>
<td>Z/55</td>
<td>7</td>
<td>Fine grained basalt, (altered).</td>
</tr>
<tr>
<td>Z/54</td>
<td>7</td>
<td>Fine grained, unaltered basalt medium to coarse grained with abundant brown chloraphoite. Texture in general, intergranular. Plagioclase composition ranging from 54 to 60% An. Pyroxene's 2 V from 45 to 50°.</td>
</tr>
<tr>
<td>Z/47</td>
<td>6</td>
<td>Medium grained unaltered basalt. Microporphyritic, phenocrysts of plagioclase more common than pyroxenes. Well formed iron titanum oxide crystals. Sub-ophitic texture common, though in general intergranular. Plagioclase composition ranging from 61 to 67% An. 2 V of pyroxenes ranging from 43 to 50°.</td>
</tr>
</tbody>
</table>
Z/46  6  Same as above with abundant iron ores.
Z/45  6  Porphyritic, phenocrysts of plagioclase ranging up to 4 mm.
Z/28  6  Similar to Z/45. Plagioclase composition ranging from 60 to 65% An. Average 2 V of pyroxene 45°.
Z/27  6  Slightly coarse than Z/23 with abundant brownish chlorophaeite. Texture in general intergranular.
Z/40  Fine grained, unaltered basalt with occasional glomeroporphyritic aggregates of plagioclases. Abundant iron ores. Plagioclase composition ranging from 60 to 69°. 2 V of pyroxenes ranging from 43 to 47°.
Z/38  Occasional olivine grains present Medium to fine grained. Intersertal texture common. Other characters same as above.
Z/38a Same as above, though slightly coarse than above.
Z/25  5  Extremely fine grained basalt. Phenocrysts rare abundant iron ores and chlorophaeite. Plagioclase composition An 65% on the average 2 V of pyroxene up to 51°. Texture in general intergranular.
Z/24  5  Same as above.
Z/20  5  Slightly coarser than Z/24. Intergranular texture with occasional glomeroporphyritic aggregates of plagioclases of composition An 60%.
Z/19  5  Fine grained basalt with sub-phosphoryritic texture. Plagioclases in glomeroporphyritic aggregates. Ground mass equigranular.
Z/14  4  Medium grained basalt with abundant microphenocrysts of plagioclases and greenish chlorophaeite. Plagioclase composition ranging from 60-66% An. 2 V of pyroxenes up to 48°.

Z/13  4  Medium grained basalt with abundant microphenocrysts of plagioclases. Microphenocrysts of pyroxenes also common. Well formed iron-ore crystals very common. Plagioclase composition ranging from 59 to 66% An.

Z/12  4  Same as above though slightly coarser than Z/13.

Z/11  3  Medium to coarse grained basalt. Intersertal texture common with abundant well formed iron ore crystals.

Z/10  3  Same as above. Plagioclase composition 60 to 65% An. 2 V of pyroxene from 43 to 54°.

Z/ 9  3  Medium grained equigranular basalt showing sub-hedral crystals of pyroxenes and plagioclases laths. Glass present relatively more than found in other samples.

Z/ 8  2  Fine grained basalt with few microphenocrysts of pyroxenes, iron ores less abundant. Texture in general sub-ophitic. Phenocrysts of plagioclase common. Plagioclase composition on the average 62% An. 2 V of pyroxenes up to 53°.

Z/ 7  2  Same as above.

Z/ 6  2  Fine grained basalt. Microphenocrysts of plagioclases in ophitic relation to pyroxenes. Well developed crystals of iron ores common.

Z/ 5  2  Fine grained basalt with intersertal texture with abundant microphenocrysts of non pleochroic brown augite. Plagioclase laths often showing flow oriented texture. Plagioclase composition ranging from An 56 to An 66%. 2 V of pyroxenes from 48 to 54°.
<table>
<thead>
<tr>
<th>Code</th>
<th>Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z/4</td>
<td>2</td>
<td>Same as above.</td>
</tr>
<tr>
<td>Z/3</td>
<td>1</td>
<td>Porphyritic basalt with abundant phenocrysts of plagioclase (up to 5 mm.). Pyroxene present only in the ground mass as granules.</td>
</tr>
<tr>
<td>Z/2</td>
<td>1</td>
<td>Porphyritic basalt, abundant golden yellow chloroaloeite. Plagioclases occurring in glomeroporphyrritic aggregates interpenetration twins. Iron ore abundant in the ground mass. Plagioclase composition An 56-64% 2 V of pyroxenes fro, 45 to 51°.</td>
</tr>
<tr>
<td>Z/1</td>
<td>1</td>
<td>Same as above.</td>
</tr>
</tbody>
</table>
The comparability of chemical analysis by different methods was investigated by the author during the project. The comparability is reasonably good for most purposes, as is evident by the different plots that follow.

**Plot 1**  
CaO : Gravimetric Vs. Atomic Absorption

**Plot 2**  
TiO₂: Spectrophotometric Vs. X.R.F.

**Plot 3**  
K₂O ; Flame photometric Vs. X.R.F.

**Plot 4**  
MgO : Atomic Absorption Vs. X.R.F.

**Plot 5**  
Trace Element Data
Comparability of BCR 1 reported results (Flanagan, 1969) with the BCR 1 results obtained by the author for the present project.

**Plot 6 - 9**  
Nickel, Niobium, Ytterium and Zirconium Emission Spectrographic Vs. X.R.F.
ARGON EXTRACTION AND ANALYSIS

The argon extraction and "clean-up" procedure described below is that used with an AEI MS. 10 mass spectrometer. The argon line is divided into four sections, each of which can be isolated from the rest of the system by metal high vacuum valves. The fusion section consists of three pyrex glass furnaces, each of which contains a silica tube surrounded by a split molybdenum radiation shield. A side arm contains tubes for the air capsules. The first "clean-up" section consists of a Cu/CuO furnace, a U-tube, a titanium sponge and the Pirani and ionisation gauges. The second "clean-up" section contains an activated charcoal finger and a titanium sponge. In the spike section, a double metal closure valve leads to the spike reservoir.

1. The fusion section is isolated from the "clean-up" and spike sections, and the two valves in the latter sections are also shut. The mercury diffusion pump heater is switched off and the liquid air trap removed. The fusion section is then let up to atmospheric pressure with dry nitrogen.
2. A fusion furnace top is cracked off, and the sample, previously weighed in a newly made molybdenum crucible, is suspended in the centre of the furnace in a molybdenum cradle from the silica tube supports. The furnace top is resealed with an oxygen-coal gas flame. The procedure is repeated for the two other furnace.

3. The fusion section is excavated with the rotary pump and the glass joints tested with an H.P. tester. If found to be vacuum tight, the liquid air trap is replaced and the diffusion pump started.

4. When the diffusion pump is operating, the "clean-up" and spike sections are reopened to the fusion section. The pressure decrease can be monitored on the Pirani gauge in the "clean-up" section.

5. With all valves open, the system is set to bake at 350°C overnight.

6. When the system has cooled, the vacuum is checked on the Pirani gauge and then with the ionisation gauge. The pressure should be better than 10^{-6} torr.

7. The second titanium sponge is out-gassed first, by heating it with the radio-frequency induction heater to red heat, for 10 minutes. The rise in pressure and its subsequent gradual decrease as the evolved gas is pumped away, is seen on the Pirani gauge. This section is then isolated from the rest of the apparatus and the first titanium is degassed similarly for 15 minutes. With all valves open the system is allowed to cool for 15 minutes.
8. With a liquid air trap on the U-tube, the vacuum is checked by the mass spectrometer on the lowest amplifier setting. Using the peak-switching device, the instrument is switched to the peak at mass 28 (nitrogen and carbon monoxide). The variable leak valve is then opened so that the extraction system is connected to the mass spectrometer. No rise in the 28 peak, or when using the half-mass switch, denotes a good vacuum. Any leaks suspected must be found and repaired.

9. With the system shut off from the pumps and the second "clean-up" section isolated, the spiking procedure is commenced. The first spike valve is opened to emit the spike (Argon-38) into the small valve between the two spike valves and one minute is allowed for the pressures to equilibrate. The first valve is closed and the second opened for one minute. The spike expands into the extraction system and the second valve is then closed. The liquid air trap is removed.

10. The larger r.f. heater coil is placed around one of the furnaces and the power switched on at its lowest setting for 5 minutes allowing the sample to warm up slowly. The power is set at maximum for 5 minutes.

11. The large coil is replaced by the smaller coil and the power increased so that the crucible temperature is at about 1300°C for about 10 minutes, and at about 1500
for 5 minutes. Sanidine samples in a fusion mixture (borax) are heated at the higher temperature for the full 15 minutes. The pressure increase is monitored on the Pirani gauge.

12. The liquid air trap is placed on the U-tube in the "clean-up" section and the Cu/CuO furnace is switched on and set at 420°C. The first Ti sponge is heated by the r.f. heater to dull red heat and allowed to cool for 10 minutes. A fall in pressure can be seen on the Pirani gauge.

13. The valve to the second "clean-up" section is opened and a cold trap is placed on the activated charcoal finger. The first cold trap is topped up and the Cu/CuO furnace is turned off.

14. After 10 minutes the system is opened to the pumps and the remaining gases removed.

15. The second "clean-up" and spike sections are isolated after 3-5 minutes and the cold traps removed. The second Ti sponge is heated to dull red heat and allowed to cool for 10 minutes.

16. The sample is now ready to be checked for purity on the mass spectrometer.

17. The mass spectrometer, set at medium amplifier sensitivity, is isolated from the ion pump and the variable leak valve opened to admit a small sample of the gas. The mass spectrometer is switched to the 23 peak and a minimum reading should be registered if the gas is pure. The mass spectrometer is then switched to the argon 40 or 38 peak,
whichever is the larger, and tuned using the half-peak switch and the fine tuner. This tunes the other peaks as well. The gas sample is pumped out of the mass spectrometer.

18. If the sample is not pure enough the gas is cleaned using the second Ti sponge. The pure sample is admitted to the mass spectrometer until Ar 38 and Ar 40 can be read on the highest amplifier range.

19. The peak-switching device and the Kienzle printer are switched to automatic. The time from the opening of the leak valve to the first complete measurement on the Ar 40 peak is noted from the chart recorder.

20. The sample is measured at peaks 40-38-36½-36-35½-40 etc. with a 10 second count time at 7 second delay time. The tuning is checked every three scans just after the Ar 38 peak is measured.

21. Eight scans are measured.

22. The mass spectrometer is open to the ion pump and the gas sample pumped away. All valves are opened on the argon line.

23. After 50 minutes the next sample may be analyzed.

24. The reloading procedure is then repeated.

25. For calibration of the spike a capsule with a measured volume of dry air is loaded in the side arm. The capsule is broken with a magnetically guided weight and the above procedure repeated with an abbreviated "clean up".

The other peaks on the peak switching device can be tuned on the air sample (high - argon - 36).
APPENDIX - 4

Sample description.

AKAR 1 - Flow 1, Sagar bore hole: Jet black, sub-norphyritic. Phenocrysts of olivine only. Ground mass extremely fine grained containing laths of plagioclase, sub-hedral grains of pyroxenes and skeletal crystals of iron ore and yellowish chloro-ecrite. Olivine present but rare.

AKAR 2 - Flow 2, Sagar bore hole: Medium grained with microphenocrysts of plagioclase as well as pyroxene. Sub-ophitic. Grains of olivine present.

AKAR 3 - Flow 5, Sagar bore hole: Extremely fine grained, phenocrysts absent.

AKAR 4 - Flow 6, Sagar bore hole: Fine grained greyish black, ground-mass very fine abundant iron ore. Phenocrysts rare.

AKAR 5 - Flow 9, Sagar bore hole: Very similar to flow 8. Microphenocrysts of plagioclase more common than pyroxenes. Olivine present but rare. Texture in general hyalophytic. Brownish grey. Microphenocrysts of plagioclase very common. Sub-ophitic, well formed iron ore crystals very common.

AKAR 13 - Flow 6, Sagar bore hole: Jet black, extremely fine grained with occasional phenocrysts of plagioclase.

AKAR 6 - Dohad Flow: Similar to the Dohad-flow.


AKAR 8 - Bhandhuka bore hole: Picritic-basalt with phenocrysts of olivines and pyroxenes.

Flow-5


AKAR 10 - Bhandhuka bore hole: Jet black, fine to medium grained rock.

AKAR 11 - Sardar dyke, Saunachtra: Greyish black, medium grained rock with ophitic texture.

AKAR 12 - 16 mile from Finariva, on Nacherrari road: