## 1-3 Results of Diamond Drill Exploration

### 1-3-1 Outline

Diamond drill operations of thirteen (13) vertical holes, the total metrage of seven hundreds and fifty (750) metres (50 metres x 11 holes and 100 metres x 2 holes), were implemented in the Buru Hill Area during the course of the current survey. Figure II – 1-5 shows the area, where diamond drill exploration works were implemented, Figure II – 1-6 for drill hole locations and Table II – 1-1 for each hole locations and hole depths.

Table II-1-1 Location of Diamond Drill Holes in the Buru Area

| DDH Number | X (mE) | Y (mN) | Elevation above sea level (m) | Hole Depth (m) |
|---|---|---|---|---|
| | UTM Coordination | | | |
| BRL - 2 | 740,812 | 9,979,463 | 1,365.5 | 100.50 |
| BRL - 3 | 740,791 | 9,979,113 | 1,332.5 | 100.70 |
| BR - 17 | 740,807 | 9,979,577 | 1,340.5 | 50.20 |
| BR - 18 | 740,687 | 9,978,815 | 1,324.0 | 50.50 |
| BR - 19 | 741,082 | 9,979,397 | 1,308.0 | 50.10 |
| BR - 20 | 741,083 | 9,979,266 | 1,312.0 | 50.20 |
| BR - 21 | 740,613 | 9,979,163 | 1,340.0 | 50.10 |
| BR - 22 | 741,080 | 9,979,148 | 1,303.5 | 50.10 |
| BR - 23 | 740,520 | 9,979,057 | 1,328.0 | 50.20 |
| BR - 24 | 740,882 | 9,979,051 | 1,315.0 | 50.50 |
| BR - 25 | 740,979 | 9,979,061 | 1,308.0 | 50.10 |
| BR - 26 | 740,496 | 9,978,948 | 1,326.0 | 50.40 |
| BR - 27 | 740,678 | 9,978,946 | 1,320.0 | 50.10 |

### 1-3-2 Diamond drill operations

(1) Mobilization, Demobilization

The drill operation team crews left Tokyo on 10th July 1989, arrived in Nairobi, Kenya, on 12th July 1989 and in Kericho on 14th July 1989, where base camps of the team members were then constructed.

The provisional works of drill operations were started on 15th July 1989. Equipments and materials of drill rigs, which had been stored in warehouse of Kisumu Office, MGD, were transported to the drill sites on 18th July 1989. The provisional works were followed by the commencement of the first hole work, BRL-2 on 21st July 1989.

The total drill operation works were successfully implemented and uneventfully completed the total programme of holes and metrages, 13 holes having a total depth of 750 metres, on 24th August 1989.

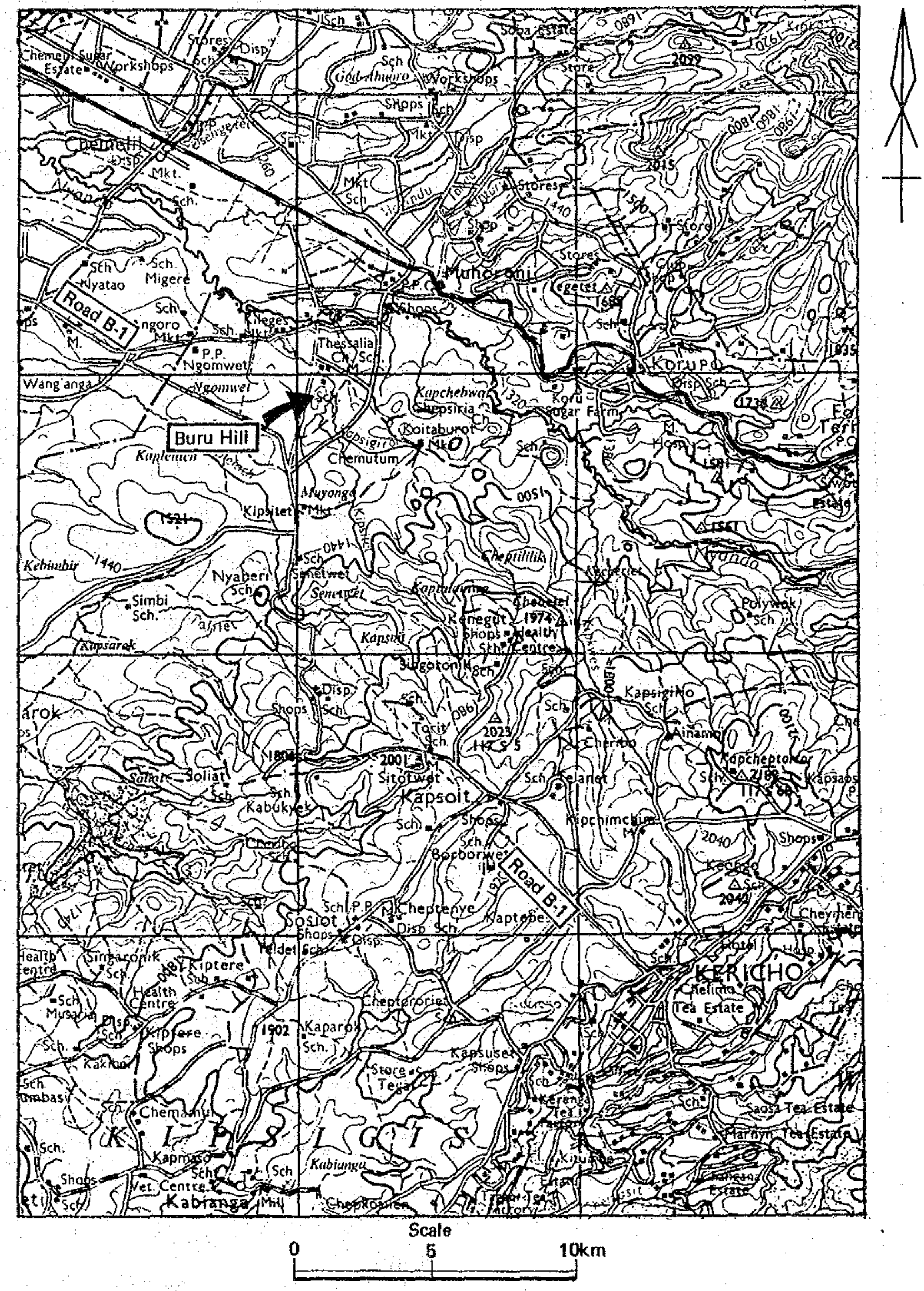



Fig. II–1–5 Location Map of Drilling Area, Buru Hill Area

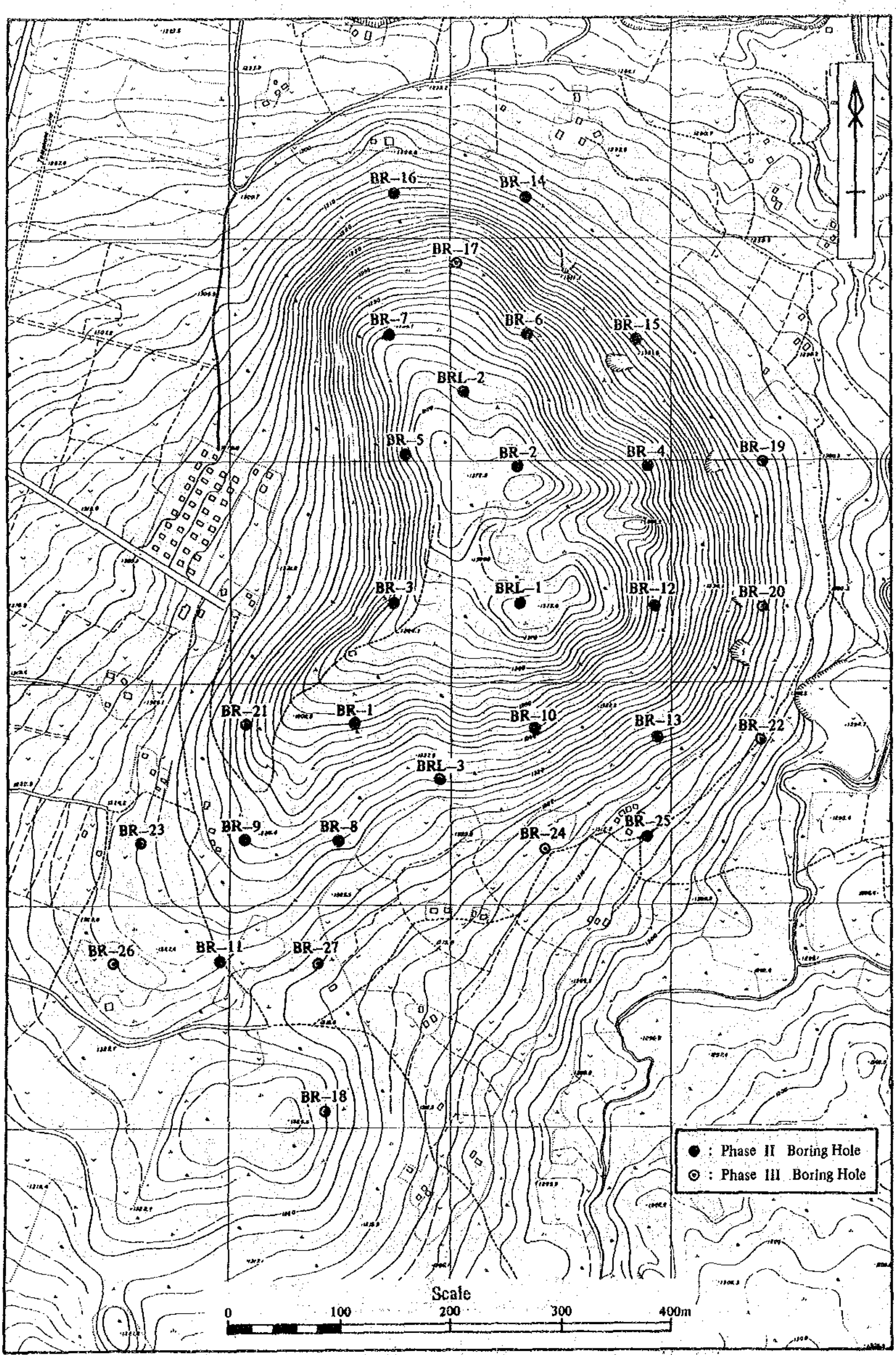



Fig. II–1–6 Location Map of the Drilling Sites in the Buru Hill Area

Mechanical checks and demobilization of drill rigs were completed on 31st August 1989. Team member crews and rigs were then removed to the Kuge-Lwala Area, to be involved in the Kuge-Lwala Programme.

The total progress and itineray of the diamond drill operation of the current survey are shown in Appendix 36.

(2) Local situations

Diamond drill operations were implemented in the Buru Hill Area. The Buru Hill, occupying an area of 800 metres east-west by 500 metres north-west, show a dome-shaped hill circumscribed by flat sugar cane fields.

Jutting carbonatite occurrences are widely observed in the Buru Hill, which are approximately 70 metres high above the sugar cane field elevation. Cars are accessible to the drill sites through the Buru Hill ridge, and surrounding, by what general transportation of equipments and materials are easily made.

Chebirir River, a tributary of Nyando River, flows down in eastern side of the Buru Hill. Water supply for drill works is available from Chebirir River.

(3) Rigs to be used and drill techniques

Two (2) sets of drill rigs were used for the current survey. An outline is as follows.

| Rig | Model | Specification | Quantity |
|---|---|---|---|
| Spindle-type, wire-line revised, high-speed rotated, engine built-in | YBM-BES, Yoshida Tekko Ltd., Japan made | 300 metres capable (non-used) | 1 |
| do. | THS-5, Tone Boring Ltd., Japan made | 400 metres capable (used) | 1 |

Caterpillar carriers were employed for moving-removing operations of drill rigs within drill sites area due to local topography and ground surface conditions.

Polyvinyl chloride pipes were used for water supply services as water head showed a 80 metres difference in maximum and a 800 metres distance. Plunger-type pumps were employed for pumping water. This is based on the past experiences, mostly in 1988 that an employment of conventional automatic suction pump may be frequently resultant in breaking out of mechanical pump troubles caused by a migration of sands and soils of considerable amount into the river water.

Basically, the wire-line technique was employed for drill works. Recoverable core diametre ranged NQ and BQ.

Rock quantities were classified into three (3) categories, hard rock i.e. gneiss and siliceous rock, semi-hard rock i.e. carbotatite rock and soft rock i.e. weathered earthy rock and overburden.

A satisfactory core recovery was achieved by the wire-line technique in the occasions of hard and semi-hard rocks, while soft rock was prone to be broken and flushed away into slime. Consequently, dry drill technique by using NX-single metal crown bit was employed for the soft rock to achieve a more satisfactory performance of core recovery.

An average bit life in an occasion of siliceous rock showed two (2) to three (3) metres per new diamond bit and drill works were of extremely heavy-duties. However, a limited occurrence of siliceous rock during the current work did not pose any serious troubles.

Appendix 39 shows quantities of drill rig, equipments and etc., Appendix 40 shows quantities of general consumables for diamond drills and diamond bits.

(4) Operation organization and personnel

Three operation parties were embodied for the current works. Two parties were for diamond drill operations and one for transportation and mounting/dismounting operatins. General organization of personnel is shown below:

| | Number of Japanese Drill Engineer | Number of Kenya Counterpart | | Number of Labour |
|---|---|---|---|---|
| 1st Drill Party | 1 | 2 | | 2 |
| 2nd Drill Party | 1 | 2 | | 2 |
| Transportation Party | 1 | - | | 5 |
| Access road construction & site preparation | (Transportation Party concurr.) | - | | 5 |
| Pump maintenance | - | Daytime<br>Night-time | 1<br>2 | 3 |
| Guard at site | - | Daytime<br>Night-time per site | 1<br>2 to 3 | 9 |
| Guard at materials storage | - | Daytime<br>Night-time | 1<br>2 | 3 |

(5) Drill operations

Drill operations were implemented by 2 shifts per 16 hours per day by embodying 2 drill parties. One transportation-mounting/dismounting party was embodied by one shift per daytime 8 hours per day.

Two drill rigs were employed during the current drill operations. While one rig was in drill operations, another rig was removed to transportation-mounting. It was effective to avoid any breaking out of work suspension and to establish a continuous drill performance. The major performances of diamond drill operations, general progresses of the whole operation are in Apx. 37, and the individual progress of each hole of the current survey are shown in Apx. 38.

### 1-3-3 Geological notes by drill holes

Geological logs of individual drill holes are shown in Apxs. 15 to 29. Geological cross section, including drill core logs, are shown in Figs. II -1-3 to II -1-4. General geology, observed in drill holes, is shown below:

(1) BRL-2 (100.50 metres deep), Apxs. 15 and 16

0 - 0.45 m : Extremely weathered rock, reddish brown.

0.45 - 21.50 m : Porous laterite, khaki, partially earthy. Fine veins and dissemination of black oxydized iron minerals are locally observed. Considered to be originated from carbonatite by chemical analysis.

21.50 - 28.90 m : Porous manganese-iron ore, dark grey to black, extremely oxidized.

28.90 - 39.30 m : Porous laterite, grey or khaki, partially disseminated by oxydized iron mineral.

39.30 - 43.50 m : Manganese-iron ore, dark grey to black, extremely oxydized.

43.50 - 49.65 m : Porous laterite, fine-grained, dark grey. Considered to be originated from iron ore or ferrocarbonatite.

49.65 - 51.00 m : Rock rich in goethite, dark brown to black. Considered to be originated from manganese-iron ores.

51.00 - 69.00 m : Porous rock, rich in goethite, pale brown, brown, dark grey or orange-brown and etc.. Considered to be originated from carbonatite by leaching. The clay bed, several ten centimetres thick at the bottom of this section is considered to be a demarcation of oxydized zone in upper part and reduction zone in lower part. Hydrostatic water table is also observed at 69 metres depth.

69.00 - 79.05 m : Massive and fine-grained carbonatite, stained to pale grey by iron oxide minerals. Fine veins of iron oxide minerals are well-developed in a whole. Bubbling reaction by diluted hydrochloric acid against calcareous character is observed beyond this section downward.

79.05 - 89.50 m : Banded and fine-grained carbonatite, pale grey, partially pale brown, greenish grey and etc.. Irregular fragments of chlorite are frequently observed. Partially brecciated. Fine veins of fine-grained alvikite of latest stage are sparsely developed.

89.50 - 91.40 m : Brecciated vitreous phonolite, grey. Intruded by chlorite fine veins, alvikite fine veins, carbonatite veins and etc..

91.40 - 95.30 m : Banded to heterogeneous carbonatite, fine-grained and grey. Grey breccias of phonolite are included.

| | | |
|---|---|---|
| 95.30 - 100.50 m | : | Vitreous phonolite with laminated banded texture, grey. Intruded by fine-grained carbonatite veins. Possibly considered to be distributed as xenoliths in carbonatite body. |

(2) BRL-3 (100.70 metres deep), Apxs. 17 and 18

| | | |
|---|---|---|
| 0 - 3.00 m | : | Extremely weathered earthy rock, reddish brown. |
| 3.00 - 7.00 m | : | Consists of intensely weathered rock in upper part, mauve-brown to olive and earthy or porous rock in lower part, khaki or brown. |
| 7.00 - 11.95 m | : | Fine-grained, banded carbonatite, brown-stained by fine veins of iron hydroxide minerals. Fine veins of iron minerals are well-developed. |
| 11.95 - 15.30 m | : | Massive ferrocarbonatite, reddish brown. |
| 15.30 - 22.40 m | : | Fine-grained banded carbonatite, brown or khaki stained. Banded texture is considered to caused by magnetite disseminations. |
| 22.40 - 23.50 m | : | Porous ferrocarbonatite, brown. |
| 23.50 - 25.50 m | : | Banded carbonatite, brown-stained. Magnetite is entirely altered to hematite or goethite. |
| 25.50 - 39.10 m | : | Fine-grained banded carbonatite, pale grey to white. Fine veins of iron hydroxide minerals are developed in a whole and are surrounded by brown stainings. |
| 39.10 - 40.70 m | : | Porous ferrocarbonatite, leached, dark grey to brown. |
| 40.70 - 45.20 m | : | Fine-grained banded carbonatite, pale grey to white. Surroundings of iron hydroxide veins are slightly brown-stained. The 45.20 m-elevation, which corresponds to hydrostatic water table, difines a demarcation of iron oxide minerals staining zone in upper zone and fresh zone in lower zone. |
| 45.20 - 58.80 m | : | Unweathered fine-grained banded carbonatite, pale grey to white. Dissemination and banded concentration of magnetite are remarkable in this section in a whole. |
| 58.80 - 71.10 m | : | Brecciated carbonatite. Breccias consist of fine-grained carbonatite, rich in fluorite, pale grey to white. Groundmass is rich in chlorite. Considered to be showing a intrusive brecciated facies. |
| 71.00 - 72.40 m | : | Porous gossan, brown to orange-brown. |
| 72.40 - 76.20 m | : | Earthy materials, greyish brown to brown. Considered to be an intensely weathered carbonatite associated with a fault. |
| 76.20 - 87.00 m | : | Brecciated heterogeneous carbonatite, pale grey to partially dark greenish grey. Chlorite fine veins are randomly well developed. |
| 87.00 - 92.70 m | : | Porous gossanous rock, brown to orange-brown. |

| | | |
|---|---|---|
| 92.70 - 98.60 m | : | Earthy to slimy materials, composed of fine-grained hematite grains and fine brown minerals. Considered to be cavity-filling materials or intensely weathered rock associated with a fault. |
| 98.60 - 100.70m | : | Alvikite, very fine-grained, pale grey. Considered to be the latest product of carbonatite mineralization. |

(3) BR-17 (50.20 metres deep), Apx. 19

| | | |
|---|---|---|
| 0 - 1.50 m | : | Intensely weathered gneiss, grey to brown. |
| 1.50 - 19.60 m | : | Intensely weathered biotite bearing granitoid gneiss, pale grey, greyish brown, khaki and etc.. Iron hydroxide veins, less than ten centimetres wide, are developed. |
| 19.60 - 22.80 m | : | Porous manganese-iron ore veins, black-stained by oxydation. Xenoliths of weathered gneiss and ferrocarbonatite are observed. |
| 22.80 - 29.80 m | : | Intensely weathered amphibole bearing gneiss, greyish green. Intruded by abundant black veins of manganese-iron ore. |
| 29.80 - 32.05 m | : | Intensely weathered porous ferrocarbonatite, brown. Partially earthy. |
| 32.05 - 34.50 m | : | Iron-manganese ore, black and partially brown. Xenoliths of granitoid gneiss are observed. |
| 34.50 - 39.50 m | : | Banded carbonatite, brown to pale khaki. Carbonate minerals are leached off by weathering. |
| 39.50 - 41.50 m | : | Brecciated granitoid gneiss. |
| 41.50 - 47.10 m | : | Porous manganese-iron ore, black. Partially brown and siliceous. |
| 47.10 - 50.20 m | : | Porous carbonatite, leached and grey to dark grey. Shows a dyke-form intrusion into granitoid gneiss. |

(4) BR-18 (52.50 metres deep), Apx. 20

| | | |
|---|---|---|
| 0 - 2.00 m | : | Intensely weathered brecciated gneiss, pale grey to khaki. |
| 2.00 - 6.10 m | : | Intensely weathered gneiss, khaki to dark grey. Shows schistose granitoid gneiss facies, associated with an abundant occurrence of iron hydroxide ore veins in a whole, khaki. |
| 6.10 - 16.70 m | : | Intensely fractured gneiss, pale brown, considered to be originated from schistose granitoid gneiss. Intense fracturings are considered to be caused by a carbonatite intrusion. An occurrence of fine veins and random net works of goethitic minerals is obvious. |
| 16.70 - 17.15 m | : | Manganese-iron ore veins, dark brown to black. |
| 17.15 - 24.80 m | : | Schistose granitoid gneiss, pale brown to pale grey. Vein mineralization and weak brecciation are observed. |

24.80 - 38.00 m : Porous laterite, rich in goethite content, dark grey to khaki. Frequently associated with gneiss breccias. Considered to be originated from carbonatite. Several iron hydroxide veins, dark brown, are obseved.

38.00 - 39.90 m : Earthy rock, dark grey in upper part and gossanous rock, brown, in lower part.

39.90 - 52.50 m : Porous leached rock, khaki to pale khaki, majorly composed of goethite. Presumably originated from carbonatite. Three ferrocarbonatite veins, leached, are observed. Xenoliths of gneiss are observed in 50.20 - 50.80 m section.

(5) BR-19 (50.10 metres deep), Apx. 21

0 - 1.00 m : Colluvial sediments.

1.00 - 3.00 m : Intensely weathered granitoid gneiss, brown.

3.00 - 9.00 m : Weakly weathered granitoied gneiss, pale grey. Porphyroclasts of pink potash feldspar are conspicuous.

9.00 - 21.00 m : Granitoid gneiss with porphyroclasts of potash feldspar. Brown iron oxide mineral stainings along cracks are faintly observed.

21.00 - 27.00 m : Intensely fractured granitoid gneiss, grey. Brecciated in lower section.

27.00 - 28.00 m : Fault fracture, associated with fine breccias of green amphibole.

28.00 - 29.00 m : Greyish green amphibolite to amphibole schist, intensely fractured.

29.00 - 36.00 m : Schistose amphibolite to amphibole schist, greyish green.

36.00 - 37.95 m : Composed of two veins of brown goethite.

37,95 - 50.10 m : Fine-grained, homogeneous amphibolite, greyish brown to greyish green. Faint brown-staining is observed, however, none of carbonatite mineralization.

(6) BR-20 (50.20 metres deep), Apx. 22

0 - 3.00 m : Colluvial sediments.

3.00 - 21.40 m : Phenitized granitoid gneiss, pale greyish brown to grey. Filmy green fine veins, aegirine likely, are well developed. Remarkably brown-stained in a whole, caused by limonitized iron oxide fine veins occurrences.

21.40 - 21.70 m : Fractured zone.

21.70 - 33.40 m : Chloritized amphibole bearing granitoid gneiss, greenish grey. Shows a heterogeneous texture by stretched chlorite occurrences.

33.40 - 34.75 m : Very fine-grained dolomitic alvikite, pale brown.

34.75 - 50.20 m : Chlorite-bearing granitoid gneiss, greenish grey. Intruded by alvikite fine veins of the latest stage.

(7) BR-21 (50.10 metres deep), Apx. 23

| | | |
|---|---|---|
| 0 - 3.80 m | : | Intensely weathered granitoid gneiss, pale grey. |
| 3.80 - 11.45 m | : | Granitoid gneiss, pale grey to white. Associated with a small quantity of porphyroclasts of potash feldspar. Intruded by several number of veins of limonitized iron oxide minerals. |
| 11.45 - 16.20 m | : | Limonitic iron ore veins, brown. Majorly composed of goethite, minorly with hematite. A small quantity of breccias of granitoid gneiss are also associated. |
| 16.20 - 17.40 m | : | Manganese-iron ore veins, dark brown. |
| 17.40 - 18.40 m | : | Crushed cores of granitoid gneiss, pale grey, were recovered. |
| 18.40 - 25.10 m | : | Schistose granitoid gneiss, pale grey. Schistose texture, caused by filmy stretchings of mica minerals, is observed. Limonite veins, less than one centimetre wide, are observed. An iron ore vein, ten centimetres wide, occurs at the section 22.60 m - 27.75 m. |
| 25.10 - 26.20 m | : | Iron ore vein, brown to dark brown. |
| 26.20 - 26.80 m | : | Granitoid gneiss. |
| 26.80 - 29.00 m | : | Porous rock, rich in goethite content, orange-brown, partially dark brown. Possibly originated from carbonatite. |
| 29.00 - 32.70 m | : | Earthy rock, rich in goethite content, dark brown to orange- brown, possibly being leached carbonatite. |
| 32.70 - 33.80 m | : | Intensely weathered manganese-iron ore, black. |
| 33.80 - 50.10 m | : | Intensely weathered earthy rock, dark grey, orange-brown, brown and dark brown. Considered to be originated from carbonatite or ferrocarbonatite. |

(8) BR-22 (50.10 metres deep), Apx. 24

| | | |
|---|---|---|
| 0 - 0.50 m | : | Overburden, dark brown. |
| 0.50 - 4.70 m | : | Intensely weathered gneiss, pale brown to khaki. |
| 4.70 - 5.00 m | : | Iron hydroxide ore vein, orange-brown. |
| 5.00 - 10.30 m | : | Intensely fractured granitoid gneiss, grey and partially orange-brown. |
| 10.30 - 15.20 m | : | Fault zone, carries breccias of fractured gneiss and a matrix of earthy khaki materials. |
| 15.20 - 18.50 m | : | Intensely fractured granitoid gneiss, pale grey. Brittle cores, mostly breccia-formed, were recovered. |
| 18.50 - 30.00 m | : | Fault zone, consists of fragments of granitoid gneiss and sandy matrix. |
| 30.00 - 41.40 m | : | Fault zone, consists of sub-pebbly breccias of chlorite-bearing granitoid gneiss and earthy greyish brown matrix. |
| 41.40 - 50.10 m | : | Fault zone, consists of fine breccias -less than three centimetres diameter- of greenish grey granitoid gneiss. Matrix was unrecoverably flushed off. |

(9) BR-23 (50.20 metres deep), Apx. 25

| | | |
|---|---|---|
| 0 - 0.50 m | : | Overburden, dark brown. |
| 0.50 - 4.40 m | : | Intensely weathered granitoid gneiss, pale grey to pale brown. |
| 4.40 - 18.45 m | : | Pale grey granitoid gneiss. Occurrences of porphyroclasts of pink potash feldspar and banded texture are conspicuous. Brown iron ore veins, less than seven centimetres wide, are sparsely observed. |
| 18.45 - 18.75 m | : | Limonitized iron oxide ore vein. |
| 18.75 - 36.40 m | : | Pale grey to white gneiss, having well-developed banded texture. Micro-folded banded texture, frequently shown by stretched porphyroclasts of potash feldspar, is observed. Brown iron oxide ore veins are observed in the sections of 30.90 m - 31.70 m and 34.85 m - 34.90 m. |
| 36.40 - 41.90 m | : | Granitoid gneiss, brown-stained by iron hydroxide minerals. |
| 41.90 - 42.80 m | : | Fractured zone, consists of gneiss fragments. |
| 42.80 - 50.20 m | : | Pale grey to white granitoid gneiss. Thin-banded texture and porphyroclasts of stretched potash feldspar and quartz are remarkable. Mineralization of carbonatite and iron oxide ore vein are really unobserved. |

(10) BR-24 (50.50 metres deep), Apx. 26

| | | |
|---|---|---|
| 0 - 1.00 m | : | Intensely weathered earthy rock, mauve-brown. |
| 1.00 - 4.10 m | : | Banded carbonatite, leached. Brown in upper half and pale grey in lower half. Fractured gneiss is at the lower-most of the section. |
| 4.10 - 5.30 m | : | Siliceous iron oxide ore vein, grey, hard and compact. |
| 5.30 - 8.00 m | : | Fine-fractured carbonatite, pale grey. Intruded by iron oxide fine vein and siliceous vein. |
| 8.00 - 10.70 m | : | Leached rock in upper half, carbonatite-originated and rich in goethite content. Siliceous iron ore in lower half, hard and compact. |
| 10.70 - 13.20 m | : | Earthy and argillaceous weathered rock, brown. Presumably originated from carbonatite or ferrocarbonatite. |
| 13.20 - 17.40 m | : | Brown leached rock in upper half, carbonatite-originated. Pale greyish siliceous ore in lower half, partially earthy. |
| 17.40 - 27.60 m | : | Limonitized leached rock, grey, khaki, brown and etc., partially earthy and argillaceous. Intruded by hard and siliceous veins, dark grey, in several locations. |
| 27.60 - 28.20 m | : | Fractured zone, consists of finely fractured gneiss, intruded by limonitized fine veins. |
| 28.20 - 31.00 m | : | Leached carbonatite, brown. Limonitized fine veins are well developed. |
| 31.00 - 37.45 m | : | Dark brown ferrocarbonatite. Fine-vein-formed intrusions into gneiss in upper half and mssive in lower half. Subjected to intense oxydation, however |

| | | |
|---|---|---|
| | | remnant carbonate minerals cause to bubbling against diluted hydrochloric acid reaction. |
| 37.45 - 42.40 m | : | Very weakly weathered carbonatite, pale greyish brown. Fine-grained and with a faint banded texture. Frequently intruded by micro-fine-grained alvikite of the latest stage. |
| 42.40 - 50.50 m | : | Unweathered fine grained carbonatite, pale grey to white. Banded texture by a banding concentration of magnetite is conspicuous. Dark grey in occasion with an abundant magnetite concentration. |

(11) BR-25 (50.10 metres deep), Apx. 27

| | | |
|---|---|---|
| 0 - 1.00 m | : | Overburden, dark brown. |
| 1.00 - 4.00 m | : | Intensely weathered schistose gneiss, grey. Chlorite bands and porphyroclasts of potash feldspar are observed. |
| 4.00 - 17.00 m | : | Schistose granitoid gneiss, pale grey to pale green. Chlorite bands are remarkably observed. Associated with sparse limonitized iron oxide ore veinings. |
| 17.00 - 31.20 m | : | Fractured granitoid gneiss, pale grey. Limonitized iron oxide fine veins are well developed. Surrouundings of veins are brown-stained. |
| 31.20 - 31.60 m | : | Limonitized iron oxide ore vein, dark brown. |
| 31.60 - 38.10 m | : | Fractured zone. Consists of fine gneiss breccias -less than one centimetre diameter- and earthy material. Granitoid gneiss is associated with chlorite bandings, well-developed. |
| 38.10 - 42.00 m | : | Fractured gneiss, pale greenish grey. |
| 42.00 - 46.00 m | : | Fractured zone, consists of fine breccias of granitoid gneiss and brown earthy material. |
| 46.00 - 50.10 m | : | Granitoid gneiss, pale grey to white. Associated with porphyroclasts of plagioclase and potash feldspar. |

(12) BR-26 (50.40 metres deep), Apx. 28

| | | |
|---|---|---|
| 0 - 1.00 m | : | Overburden, dark brown. |
| 1.00 - 3.00 m | : | Intensely weathered granitoid gneiss, pale grey. |
| 3.00 - 14.80 m | : | Granitoid gneiss, pale grey to greyish white. Remarkably associated with porphyroclasts of pink potash feldspar. Faint mineralization of fine limonite veins are widely distributed in a whole. Locally fractured. |
| 14.80 - 39.80 m | : | Granitoid gneiss, pale grey to greyish white, associated with porphyroclasts of potash feldspar. Cracks, filled up by limonite, are sparsely developed in a whole. |

39.80 - 50.40 m : Granitoid gneiss, pale grey to white. Dissociated from mafic minerals and porphyroclasts of potash feldspar. Considered to be originated from aplitic fine-grained granite.
Three veins of iron oxide ore, orange-brown, are observed in the section 44.20 m - 47.70 m.

(13) BR-27 (50.50 metres deep), Apx. 29

0 - 0.50 m : Overburden, dark brown.

0.50 - 4.10 m : Intensely weathered granitoid gneiss, brown.

4.10 - 13.60 m : Intensely fractured granitoid gneiss, brown-stained. Associated with cracks, filled up by brown materials, rich in goethite content.

13.60 - 15.90 m : Siliceous iron ore vein, brown. Associated with fine breccias of gneiss.

15.90 - 19.50 m : Fractured gneiss, brown-stained. Filled up by brown matrix, rich in goethite content.

19.50 - 21.70 m : Siliceous iron ore vein, brown. Associated with fine breccias of gneiss.

21.70 - 23.10 m : Earthy rock, pale brown. Presumably originated from carbonatite.

23.10 - 25.20 m : Earthy rock, brown, rich in goethite content. Presumably originated from ferrocarbonatite.

25.20 - 31.10 m : Intensely weathered earthy rock, brown to pale brown. Presumably originated from carbonatite.

31.10 - 39.00 m : Intensely weathered earthy rock, dark greyish brown, partially brown. Somewhat possible to be of cavity-filling materials.

39.00 - 40.10 m : Greyish brown earthy rock. Considered to be originated from carbonatite.

40.10 - 44.50 m : Fractured granitoid gneiss, pale grey.

44.50 - 47.50 m : Dark brown to orange-brown rock, rich in goethite content. Partially siliceous.

47.50 - 49.50 m : Fractured gneiss, grey. Limonitic fine veins are well developed.

49.50 - 50.50 m : Earthy brown rock. Presumably originated from carbonatite.

### 1-3-4 Mineralization

After the interpretations of the results of diamond dril exploration works, it has been proved that the mineralizatio of REE in the Buru Hill Area is to be devided into two categories, those are: 1) A concentratin of REE minerals, associated with primary carbonatitic rock and 2) Supergene enrichment of REE by weathering of carbonatitic rock.

(1) Primary mineralizzation

It is devided into that; carbonatite, ferrocarbonatite, calcareous iron ore vein, manganiferrous iron ore vein and siliceous iron ore vein

Carbonatite: Carbonatite is distributed in a whole area of the Bru Hill Meneralized Zone. Frequent behaviour of general occurrence of carbonatite shows that it fomrs a massive body in central portion of the body and forms dykes in marginal and/or upper portion of the body. Carbonatite is observed on ground surface in the area in several small outcrops, caused by an intense weathering, oxydation and lateritization. Unweathered facies of massive carbonatite body is properly observed below the elevation of water table. Unusually, unweathered carbonatite is observed by diamond drill holes BR-1 and BRL-3 in shallow depths under the ground surface, where permeation of ground water into massive carbonatite body, with less occurrence of cracks, might be low.

Carbonatite, in general, shows pale grey, fine - to medium-grained and is brown-stained in oxydized zone. It also shows a banded and/or massive texture, relatively homogeneous, however, a brecciated facies is observed in lower portion of the body by diamond drill holes, BRL-1 and BRL-3. Carbonatite is majorly composed of carbonate minerals, associated with barite, fluorite and magnetite, and with a small quantity of pyrochlore and REE minerals.

. Ferrocarbonatite: Ferrocarbonatite generally shows an occurrence of dykes, several ten (10) centimatres to several metres wide usually, ten (10) metres wide in maximum, in the form of intersections into carbonatite body. Ferrocarbonatite is also generally observed in close geological association with calcareous and/or manganiferrous iron ore veins, however, shows less frequent occurrences than those with iron ore veins. Ferrocarbonatite, in general, may likely show a convergent occurrence in an upper portion of massive carbonatite body. Ferrocarbonatite is generally fine- to medium-grained, brown and reddish brown in an oxidized zone, majorly composed of carbonate minerls. Ferrocarbonatite more or less shows a porous facies compared with carbonatite.

. Calcareous iron ore vein: Calcareous iron ore veins are observed in a whole area of the mineralized zones, in the forms of veins, five (5) metres wide in maximum, usually several ten (10) centimetres to several metres wide or of networks less than ten (10) centimetres wide. Calcareous iron ore veins are observed in the forms of irregular swarms of veins and/or networks that intersect into carbonatite body through the fissures, which were formed during the process of the carbonatite intrusion. It is usually variegated such as dark brown, reddish brown, brownish orange-coloured, dark grey and etc., and as also porous, very fine-grained, hard and dense and etc.. Calcareous ore is majorly composed of iron minerals, minorly associated with carbonate minerals. Iron minerals are usually weathered in the form of limonite, mostly of goethite.

- Manganiferrous iron ore vein: Manganiferrous iron ore veins show a similar occurrence to that of calcareous iron ore veins. Manganiferrous iron ore is easily distinguished from calcareous iron ore by showing a peculiar black tint, caused by a containment of manganese. Manganiferrous iron ore is usually porous and brittle, resulted from a behaviour of a convergent occurrence in an upper portion of carbonatite body, where oxydatio of ore is steadily made.

- Siliceous iron ore vein: Siliceous iron ore veins are observed on ground surface in the area and also in drill cores, carried out in central to northern portions in Buru Hill Area. Siliceous iron ore veins generally show an occurrence in the form of dykes, less than ten (10) metres wide, usually one (1) to several metres wide. It is proved by the results of diamond drill works that siliceous iron ore veins form a swarm of ore veins, one (1) to five (5) metres wide each, what is likely observed on ground surface that is having a width of more than twenty (20) metres.
  Siliceous iron ore vein is of very fine-grained, hard and dense, and is pale grey to brownish orange-coloured or dark grey. It is majorly composed of iron minerals and quartz. Quartz is mostly of chalcedonic.

(2) Supergene enrichment

Supergene enrichment in the Buru Hill Area might be under the control of geological processes by weathering and water-borne categries, i.e., a concentration of minerals by weathering and also a downward concentration of metallic elements dissolved in water in an oxydation zone. It hs been conducted by the diamond drill works carried out in the second-year programme 1988 that the current elevation of ground water table in the whole Buru Hill Area is to be situated on 1.295 metres high above sea level approximately and has been elucidate by the interpretations of mode of oxydation of iron minerals that the rocks located on lower elevation than that of the current ground water table may also ever be located on lower elevation than that of the ground water table of the past geological time. It is also proved by the current programme works 1989 that the current elevation of ground water table is situated on 1.285 metres to 1,300 metres high above sea level, meanwhile, slightly higher in central portion of the Buu Hill Area and tends to be slightly deeper toward its surroundings.

In accordance with a fact that an occurrence of unweathered carbonatite body is situated on lower elevation than that of the ground water table, supergene-enriched zone should be reasonably considered to be located in the oxydation zone, on higher elevation than the ground water table, what also show a coincidence with the results of chemical analyzes of ores. Weathered products in the area include soil and/or argillized rocks near ground surface and leached carbonatite body to the approximate depth of the ground water table.

Soil and/or argillized rocks near ground surface:

Lateritic surface soil and/or argillized rocks, primary rocks of which are hardly identified, are observed in most sections of drill cores, showing several to six (6) metres thick, twenty (20 metres thick in maximum in the flat land of southern Buru Hill. A concentration of pyrochlore, which is resistive to chemical weathering, is observed in the units.

Leached carbonatite in oxydation zone from ground surface toward ground water table:

Carbonatite body has been subjected to the mineralizations of later stage by the modes of veinings, networks and disseminations, which has furhter been followed by intense weathering on ground surface and oxydation. Meanwhile, an identification of original rock, which is subjected to weathering, is very difficult, due to an intense alteration of mineral assemblage and facies, such as that most of carbonate minerals are subjected to leaching, iron minerals are weathered to iron hydroxide minerals, major facies frequently shows of earthy, porous, gossanous and etc.. The petrological examinations of original rocks, which are heavily weathered, have been carried out based on the research of remnant rock fragments by the second-year programme. Gneiss was also partially classified in the original rock. However, it has been found by the current work that gneiss, observed in the form of rock fragments, is to be interpreted to be the fragmental xenoliths, which are contained in lesser amount. It is also found after the examinations of chemical assay results on ores as follows that most of weathered rocks in the mineralized zone are of carbonatite-originated. Carbonatite in the oxydized zone is considered to be undergone a decrease in weight and volume, and to be subjected to superzene enrichment by downward relocation and reprecipitation of the soluble elements.

## 1-4 Results of Chemical Analyses of Ores

### 1-4-1 Sampling and chemical analyses of ores

The 162 ore samples, intersected by the current diamond drill works, were collected to be chemically analysed.

Eight (8) rare earths elements, lanthanum (La), cerium (Ce), neodymium (Nd), samarium (Sm), europium (Eu), telbium (Tb), ytterbium (Yb) and lutecium (Lu), and other related seven (7) elements, phosphorus (P), barium (Ba), strontium (Sr), niobium (Nb), yttrium (Y), uranium (U) and thorium (Th) were chemically analysed. Chemical analyses of Ore Grade-percent-unit was applied to barium and LREE (La, Ce, Nd), which are contained in high concentration, and Trace Level-parts per million-unit was applied to the other elements.

The general methods of chemical analysis and specifications are shown in Table II-1-2.

**Table II-1-2 Analytical Method, Detection Limit and Upper Limit**

| | | Description | Method | Detection limit | Upper limit |
|---|---|---|---|---|---|
| U | ppm: | Trace level | NAA | 0.2 | 100.0 |
| Th | ppm: | Trace level | NAA | 0.1 | 10,000 |
| La | %: | Ore grade | NAA | 0.001 | 100.0 |
| Ce | %: | Ore grade | NAA | 0.01 | 100.0 |
| Nd | %: | Ore grade | NAA | 0.01 | 50.0 |
| Sm | ppm: | Tracer level | NAA | 0.1 | 500 |
| Eu | ppm: | Tracer level | NAA | 0.5 | 100.0 |
| Tb | ppm: | Tracer level | NAA | 0.1 | 100.0 |
| Yb | ppm: | Gamma counting | NAA | 0.1 | 1,000 |
| Lu | ppm: | Tracer level | NAA | 0.1 | 500 |
| Nb | ppm: | Trace level | XRF | 5 | 10,000 |
| Sr | ppm: | Trace level | ICP-AES | 1 | 10,000 |
| Y | ppm: | Trace level | XRF | 5 | 10,000 |
| Ba | %: | Ore grade | NAA | 0.01 | 100.0 |
| P | ppm: | Trace level | ICP-AES | 10 | 10,000 |

XRF: *X-ray fluorescence analysis*

NAA: Neutron activation analysis

ICP-AES: Inductively coupled plasma - Atomic emission spectrometry

### 1-4-2 Statistical values of the elements and interpretations

(1) Statistical values

The statistical values of fifteen (15) elements on the 162 samples in total by the current work are listed in Table II-1-3. The average values of chemical contents of the elements on 162 samples the above are mostly equal to those on 210 samples by the second-year work 1988, by what the chemical contents of the elements in mineralized zones are estimated to be fairly uniform.

Phosphorus, chemical analysis of which was omitted by the second-year work 1988, shows an average content of 3377 ppm, to be re-calculated to 7765 ppm of $P_2O_5$. This is a very low content of phosphorus in comparison with an ore grade of the mine world-wide, where phosphorus is operated as a major product or a by-product.

The average content values of five LREE, La, Ce, Nd, Sm and Eu, in the form of oxide, and the quantitative ratio are shown in Table II-1-4. The ratio provides a sufficient coincidence to that in the occasion of bastnaésite concentrate of the Mountain Pass mine, U.S.A.. It is, consequently, estimated that the REE minerals in Homa Bay area are majorly composed of bastnaésite. However, the $Y_2O_3$ content in $TRE_2O_3$ in Homa Bay area occupies some 3.5 percent, meanwhile, extremely higher than that in the occasion of the Mountain Pass mine, 0.09 percent. It may also pose a possibility of an occurrence of bastnaésite-Y, (Y, Ce) $(CO_3)$ F, in Homa Bay area.

Table II-1-4 Distribution of rare earths in ores

| Light REO | Bastnaésite concentrate,*1 REO percent | Average value of ore by current work, REO percent |
|---|---|---|
| $La_2O_3$ | 33.2 | 32.3 |
| $CeO_2$ | 49.1 | 47.6 |
| $Pr_6O_{11}$ | 4.3 | 4.3 *2 |
| $Nd_2O_3$ | 12.0 | 13.6 |
| $Sm_2O_3$ | 0.78 | 1.3 |
| $Eu_2O_3$ | 0.11 | 0.4 |
| Total | 99.49 | 99.49 *2 |
| Heavy REO | 0.318 | - |

*1 by Henderson (Ed.) (1984): Rare Earth Element Geochemistry

*2 Estimated value after *1

Table II–1–3 Summary of Statistics of Analysis – Drill Core Samples –

| Component | Unit | No. of sample | Maximum | Minimum | Mean(m) | Standard deviation | m − 26 | m − σ | m + σ | m + 2σ |
|---|---|---|---|---|---|---|---|---|---|---|
| P | PPM | 162 | 36500 | 236 | 3376.7 | 0.445 | 434.8 | 1211.7 | 9410.1 | 26223.8 |
| BA | % | 162 | 11.80 | 1.00 | 3.648 | 0.2243 | 1.299 | 2.177 | 6.114 | 10.247 |
| SR | PPM | 162 | 29600 | 226 | 1538.8 | 0.303 | 381.0 | 765.7 | 3092.5 | 6214.9 |
| NB | PPM | 162 | 4450 | 62 | 730.2 | 0.311 | 174.0 | 356.4 | 1496.0 | 3065.0 |
| Y | PPM | 162 | 1950 | 105 | 587.9 | 0.166 | 273.2 | 400.7 | 862.5 | 1265.3 |
| U | PPM | 162 | 180.1 | 5.4 | 27.96 | 0.339 | 5.87 | 12.81 | 61.04 | 133.27 |
| TH | PPM | 162 | 2084.0 | 197.0 | 787.82 | 0.170 | 359.40 | 532.11 | 1166.41 | 1726.92 |
| LA | % | 162 | 2.260 | 0.061 | 0.5172 | 0.2966 | 0.1320 | 0.2613 | 1.0239 | 2.0271 |
| CE | % | 162 | 2.24 | 0.10 | 0.763 | 0.2168 | 0.281 | 0.463 | 1.256 | 2.069 |
| ND | % | 162 | 0.50 | 0.03 | 0.218 | 0.1787 | 0.096 | 0.145 | 0.329 | 0.497 |
| SM | PPM | 162 | 427.0 | 42.0 | 206.61 | 0.142 | 107.51 | 149.04 | 286.42 | 397.06 |
| EU | PPM | 162 | 198.0 | 10.9 | 69.06 | 0.175 | 30.87 | 46.17 | 103.30 | 154.52 |
| TB | PPM | 162 | 77.6 | 2.6 | 19.62 | 0.232 | 6.74 | 11.50 | 33.48 | 57.14 |
| YB | PPM | 162 | 82.1 | 4.8 | 25.83 | 0.190 | 10.74 | 16.66 | 40.05 | 62.10 |
| LU | PPM | 162 | 16.5 | 1.1 | 4.38 | 0.169 | 2.01 | 2.97 | 6.46 | 9.53 |

Table II–1–4 Distribution of Rare Earths in Ores

| | P | BA | SR | NB | Y | U | TH | LA | CE | ND |
|---|---|---|---|---|---|---|---|---|---|---|
| P | 1.0000 | 0.4298 | 0.3457 | 0.3082 | 0.1943 | 0.0458 | -0.1407 | 0.5141 | 0.4376 | 0.2385 |
| BA | 0.4298 | 1.0000 | 0.0794 | 0.1919 | 0.1858 | 0.1798 | 0.2265 | 0.6171 | 0.6298 | 0.5640 |
| SR | 0.3457 | 0.0794 | 1.0000 | -0.0073 | 0.1932 | 0.0873 | 0.0526 | 0.4050 | 0.3673 | 0.1844 |
| NB | 0.3082 | 0.1919 | -0.0073 | 1.0000 | 0.1661 | 0.1371 | -0.0354 | 0.2569 | 0.1466 | 0.0231 |
| Y | 0.1943 | 0.1858 | 0.1932 | 0.1661 | 1.0000 | 0.2428 | 0.6013 | 0.2966 | 0.3668 | 0.4578 |
| U | 0.0458 | 0.1798 | 0.0873 | 0.1371 | 0.2428 | 1.0000 | 0.3969 | 0.3789 | 0.4806 | 0.5124 |
| TH | -0.1407 | 0.2265 | 0.0526 | -0.0354 | 0.6013 | 0.3969 | 1.0000 | 0.1825 | 0.3280 | 0.5417 |
| LA | 0.5141 | 0.6171 | 0.4050 | 0.2569 | 0.2966 | 0.3789 | 0.1825 | 1.0000 | 0.9371 | 0.6084 |
| CE | 0.4376 | 0.6298 | 0.3673 | 0.1466 | 0.3668 | 0.4806 | 0.3280 | 0.9371 | 1.0000 | 0.8188 |
| ND | 0.2385 | 0.5640 | 0.1844 | 0.0231 | 0.4578 | 0.5124 | 0.5417 | 0.6084 | 0.8188 | 1.0000 |
| SM | 0.0248 | 0.1918 | 0.1010 | -0.0278 | 0.5860 | 0.4416 | 0.6785 | 0.2145 | 0.4269 | 0.7782 |
| EU | 0.0250 | 0.2026 | 0.2191 | 0.0586 | 0.6941 | 0.4667 | 0.7126 | 0.3007 | 0.4518 | 0.6726 |
| TB | -0.0271 | 0.0695 | 0.1180 | 0.1263 | 0.7348 | 0.3599 | 0.5925 | 0.1095 | 0.2179 | 0.4056 |
| YB | 0.3312 | 0.1608 | 0.1315 | 0.1420 | 0.8213 | 0.0013 | 0.3143 | 0.1691 | 0.1897 | 0.2350 |
| LU | 0.4423 | 0.1590 | 0.2580 | 0.2003 | 0.7740 | 0.2215 | 0.3400 | 0.3475 | 0.3601 | 0.3357 |

| | SM | EU | TB | YB | LU |
|---|---|---|---|---|---|
| P | 0.0248 | 0.0250 | -0.0271 | 0.3312 | 0.4423 |
| BA | 0.1918 | 0.2026 | 0.0695 | 0.1608 | 0.1590 |
| SR | 0.1010 | 0.2191 | 0.1180 | 0.1315 | 0.2580 |
| NB | -0.0278 | 0.0586 | 0.1263 | 0.1420 | 0.2003 |
| Y | 0.5860 | 0.6941 | 0.7348 | 0.8213 | 0.7740 |
| U | 0.4416 | 0.4667 | 0.3599 | 0.0013 | 0.2215 |
| TH | 0.6785 | 0.7126 | 0.5925 | 0.3143 | 0.3400 |
| LA | 0.2145 | 0.3007 | 0.1095 | 0.1691 | 0.3475 |
| CE | 0.4269 | 0.4518 | 0.2179 | 0.1897 | 0.3601 |
| ND | 0.7782 | 0.6726 | 0.4056 | 0.2350 | 0.3357 |
| SM | 1.0000 | 0.8574 | 0.5982 | 0.3390 | 0.3953 |
| EU | 0.8574 | 1.0000 | 0.7060 | 0.3982 | 0.4360 |
| TB | 0.5982 | 0.7060 | 1.0000 | 0.5359 | 0.4849 |
| YB | 0.3390 | 0.3982 | 0.5359 | 1.0000 | 0.7927 |
| LU | 0.3953 | 0.4360 | 0.4849 | 0.7927 | 1.0000 |

Table II–1–6 Summary of Principal Component Analysis – Drill Core Samples –

| Prin. compo- nent | Eigen value | Contri- bution | Cum. contri- bution | | P | BA | SR | NB | Y | U | TH | LA | CE | NO | SM | EU | TB | YB | LU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.166 | 0.411 | 0.41 | Eigen vector | 0.144 | 0.196 | 0.131 | 0.079 | 0.327 | 0.217 | 0.275 | 0.255 | 0.302 | 0.332 | 0.312 | 0.333 | 0.277 | 0.242 | 0.279 |
| | | | | Factor loading | 0.357 | 0.487 | 0.326 | 0.197 | 0.813 | 0.538 | 0.683 | 0.634 | 0.751 | 0.823 | 0.775 | 0.826 | 0.688 | 0.601 | 0.693 |
| | | | | Contribution | 0.128 | 0.238 | 0.106 | 0.039 | 0.661 | 0.290 | 0.466 | 0.401 | 0.563 | 0.678 | 0.600 | 0.682 | 0.473 | 0.361 | 0.481 |
| 2 | 2.493 | 0.166 | 0.58 | Eigen vector | -0.397 | -0.353 | -0.196 | -0.169 | 0.210 | -0.018 | 0.265 | -0.430 | -0.348 | -0.104 | 0.218 | 0.218 | 0.315 | 0.149 | 0.050 |
| | | | | Factor loading | -0.628 | -0.557 | -0.310 | -0.267 | 0.332 | -0.029 | 0.418 | -0.679 | -0.550 | -0.164 | 0.344 | 0.344 | 0.497 | 0.236 | 0.079 |
| | | | | Contribution | 0.394 | 0.311 | 0.096 | 0.071 | 0.110 | 0.001 | 0.174 | 0.461 | 0.303 | 0.027 | 0.118 | 0.118 | 0.247 | 0.056 | 0.006 |
| 3 | 1.880 | 0.125 | 0.70 | Eigen vector | 0.335 | -0.098 | 0.119 | 0.231 | 0.270 | -0.313 | -0.200 | -0.059 | -0.172 | -0.292 | -0.217 | -0.147 | 0.068 | 0.484 | 0.417 |
| | | | | Factor loading | 0.459 | -0.134 | 0.163 | 0.317 | 0.371 | -0.430 | -0.275 | -0.081 | -0.237 | -0.401 | -0.297 | -0.201 | 0.093 | 0.663 | 0.572 |
| | | | | Contribution | 0.211 | 0.018 | 0.026 | 0.100 | 0.137 | 0.185 | 0.075 | 0.007 | 0.056 | 0.160 | 0.088 | 0.040 | 0.009 | 0.440 | 0.327 |
| 4 | 1.060 | 0.071 | 0.77 | Eigen vector | 0.028 | -0.215 | 0.661 | -0.680 | -0.005 | -0.186 | -0.032 | 0.036 | 0.068 | 0.017 | 0.038 | 0.046 | -0.079 | 0.008 | 0.048 |
| | | | | Factor loading | 0.029 | -0.222 | 0.680 | -0.700 | -0.005 | -0.192 | -0.033 | 0.037 | 0.070 | 0.017 | 0.039 | 0.048 | -0.081 | 0.009 | 0.049 |
| | | | | Contribution | 0.001 | 0.049 | 0.463 | 0.490 | 0.000 | 0.037 | 0.001 | 0.001 | 0.005 | 0.000 | 0.002 | 0.002 | 0.007 | 0.000 | 0.002 |
| 5 | 0.894 | 0.060 | 0.83 | Eigen vector | -0.029 | -0.471 | 0.459 | 0.447 | -0.061 | 0.474 | -0.097 | 0.044 | -0.032 | -0.181 | -0.055 | 0.099 | 0.158 | -0.235 | 0.003 |
| | | | | Factor loading | -0.027 | -0.446 | 0.434 | 0.422 | -0.058 | 0.448 | -0.092 | 0.042 | -0.030 | -0.171 | -0.052 | 0.093 | 0.150 | -0.222 | 0.002 |
| | | | | Contribution | 0.001 | 0.199 | 0.188 | 0.178 | 0.003 | 0.201 | 0.008 | 0.002 | 0.001 | 0.029 | 0.003 | 0.009 | 0.022 | 0.049 | 0.000 |
| 6 | 0.593 | 0.040 | 0.87 | Eigen vector | 0.124 | -0.251 | -0.372 | -0.395 | -0.014 | 0.603 | -0.213 | 0.028 | 0.081 | 0.024 | -0.056 | -0.203 | -0.147 | 0.125 | 0.358 |
| | | | | Factor loading | 0.096 | -0.193 | -0.287 | -0.304 | -0.011 | 0.464 | -0.164 | 0.022 | 0.062 | 0.018 | -0.043 | -0.157 | -0.113 | 0.097 | 0.276 |
| | | | | Contribution | 0.009 | 0.037 | 0.082 | 0.093 | 0.000 | 0.215 | 0.027 | 0.000 | 0.004 | 0.000 | 0.002 | 0.025 | 0.013 | 0.009 | 0.076 |
| 7 | 0.503 | 0.034 | 0.91 | Eigen vector | 0.525 | -0.166 | -0.062 | 0.092 | -0.191 | -0.109 | -0.278 | -0.312 | -0.163 | 0.250 | 0.538 | 0.219 | -0.156 | -0.100 | -0.025 |
| | | | | Factor loading | 0.372 | -0.118 | -0.044 | 0.066 | -0.135 | -0.078 | -0.197 | -0.222 | -0.116 | 0.177 | 0.382 | 0.156 | -0.111 | -0.071 | -0.018 |
| | | | | Contribution | 0.139 | 0.014 | 0.002 | 0.004 | 0.018 | 0.006 | 0.039 | 0.049 | 0.013 | 0.031 | 0.146 | 0.024 | 0.012 | 0.005 | 0.000 |

(2) Interpretations of mutual correlation

Mutual correlation coefficients among fifteen (15) elements are shown in Table II-1-5. Abbreviations of the elements are shown below:

LREE : Light rare earth element; La, Ce, Nd

MREE : Middle rare earth element; Sm, Eu, Tb

HREE : Heavy rare earth element; Yb, Lu

REE : Total rare earth element

i) P is correlated to LREE and HREE weakly.

ii) Ba is correlated to P and LREE moderately and Nb is correlated to P weakly.

U is correlated to Th and LREE-MREE moderately or weakly.

iii) Y, Th and REE are mutually correlated moderately or highly.

Particularly;

Y; Highly correlated to MREE-HREE, from Eu to Lu.

Th: Highly correlated to LREE-MREE, from Nd to Tb.

LREE; Mutually correlated highly, meanwhile, Nd is highly correlated to MREE, from Sm to Eu.

HREE; Highly mutually correlated to the elements among the group.

(3) Principal component analysis

It is uneasy to reveal a mutual relation of chemical elements, solely by an estimation of correlation coefficients among the elements due to that of an abundant total number, fifteen (15), of the elements of chemical analysis. Based on the above, the principal component analysis was carried out to summarize the total data of chemical analysis. The summarized results of the above are shown in Table II-1-6, from the 1st principal component to the 7th. The cumulative contribution, made by the 1st, 2nd and 3rd principal components, occupies a 70 percent of the total contribution, by what it is shown that the comprehensive behaviours of chemical characters of the elements should be wholly represented by the three components the above.

The 1st principal component: It represents a 41 percent of the total data of chemical analysis. It is determined by the factor loading values of Y, U, Th and REE, 0.538 to 0.826, which are of the major component elements of REE minerals. It is estimated that the 1st principal component should represent a behaviour of concentration of the REE minerals.

The 2nd principal component: Phosphorus and barium show moderate to weak correlations to La and Ce, as revealed after a mutual correlation analysis.

The 3rd principal component: Phosphorus shows a weak mutual correlation to Heavy REE, similar to that of the 2nd principal component.

It may possibly show after a comprehensive interpretation of the behaviour of the 1st and 2nd principal components that phosphorus may be limitedly related to the chemical concentration of REE minerals, i.e. the primary mineralization, however be concentrated under the condition, where Light REE and Heavy REE are concentrate, inversely, Middle REE is diluted, i.e. in upper portion of the weathering and leaching zone, as noted in the 2nd-year report 1988.

### 1-4-3 Chemical assay results of drill cores

(1) Total samples

The weighted average values of chemical contents of the elements, (Sum of Content × Width) / (Sum of Width), on the 162 samples for chemical analysis, are shown in Table II-1-7.

The values of major elements are: 952 ppm of Nb, 608 ppm of Y, 1.79 percent of La + Ce + Nd, 311 ppm of Sm + Eu + Tb and 31 ppm of Yb + Lu, respectively.

(2) Chemical contents of the elements shown by each drill hole

The weighted average chemical values of the fifteen (15) elements shown by each drill hole are listed in Table II-1-7. It is shown that the mineralization is strong in the periphery of the carbonatite body located in the south of Buru Hill, meanwhile, it is weak in the central portion of the drill sites area, where two holes, BRL-2 and BRL-3 were operated. It is estimated that a low showing of the metallic element contents by the two holes the above is caused by intersections of holes into unweathered portions of the carbonatite body, where supergene enrichment of the elements is poor, what results in a low showing of the total contents of the elements.

(3) Vertical variation of the element contents by each drill hole

The diagrams, which show the modes of vertical variations of Nb, Y, Th, La + Ce + Nd, Sm + Eu + Tb and Yb + Lu, are provided to estimate the behaviours of movement of the elements, the above, in a carbonatite body by weathering.

A content of the elements in mineralized zone is considered to be firstly dependent on the natural content of the elements by primary mineralization, secondarily followed by a movement of the elements by oxydation-reduction. The vertical variations of the element distribution should be properly elucidated by the mineralogy of continuously recovered drill cores, which initially penetrates an oxydation zone, followed by a sufficient intersection deeply into a reduction zone. Drill holes, BRL-2 and BRL-3 by the current work are to be selected to provide the pertinent drill cores for the interpretations of the object the above (Figs. II-1-7 and II-1-8).

BRL-2: The ground water table, located on some 1.295 metres high above sea level, clearly defines a demarcation of mode of element concentrations, i.e., the elements or the group of elements are concentrated above the ground water table, meanwhile, are not concentrated below it.

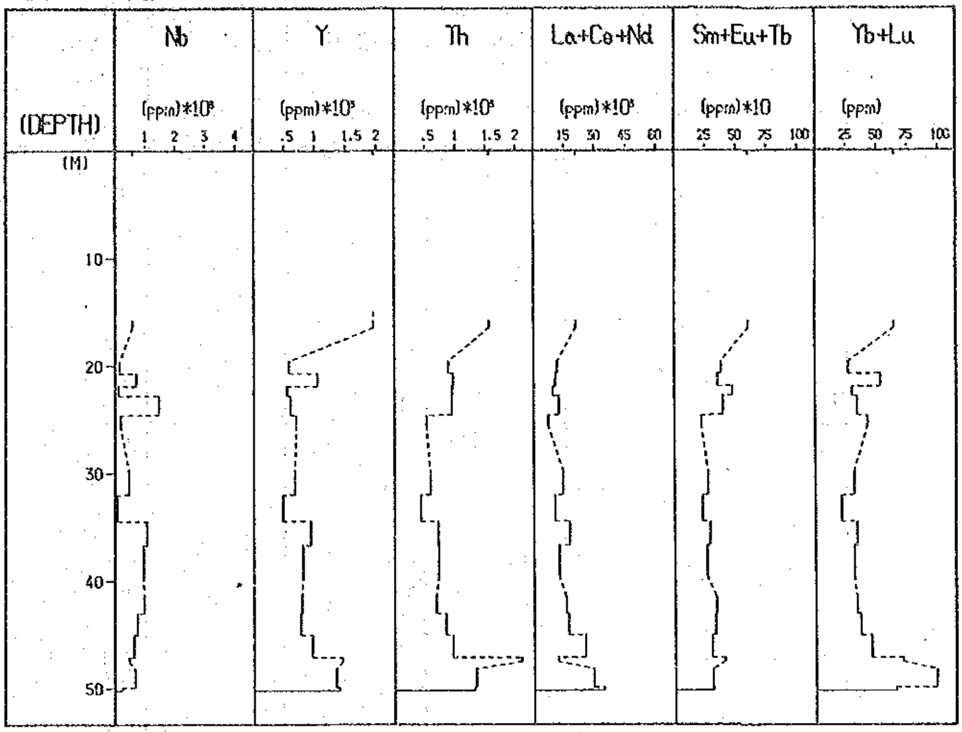
BRL-3: The vertical variations of the distribution of element contents, other than Nb, are obscure. It coincides with that the carbonatite body in the area of Hole BRL-3 is little subjected to weathering in the portion above the ground water level.

Table II–1–7 Average Value of Elements and Components by Drill Hole

| DDH No. | Number of Samples | Total length Analyzed (m) | P (ppm) | Ba (%) | Sr (ppm) | Nb (ppm) | Y (ppm) | U (ppm) | Th (ppm) | La (ppm) | Ce (ppm) | Nd (ppm) | Sm (ppm) | Eu (ppm) | Tb (ppm) | Yb (ppm) | Lu (ppm) | La+Ce+Nd (ppm) | Sm+Eu+Tb (ppm) | Yb+Lu (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRL-2 | 31 | 93.15 | 1607.8 | 3.428 | 2085.1 | 965.5 | 567.2 | 73.05 | 1027.74 | 5729.3 | 8532.0 | 2459.8 | 228.77 | 89.23 | 25.17 | 19.87 | 3.56 | 16721.1 | 343.17 | 23.43 |
| BRL-3 | 33 | 101.10 | 9128.8 | 3.940 | 3664.9 | 758.8 | 598.0 | 18.84 | 683.76 | 6663.8 | 8010.9 | 2005.9 | 199.53 | 69.35 | 19.68 | 30.07 | 4.88 | 16680.6 | 288.56 | 34.95 |
| BR-17 | 16 | 24.25 | 2451.7 | 2.743 | 1944.1 | 656.9 | 838.6 | 32.14 | 834.10 | 5622.3 | 7872.6 | 2292.0 | 213.69 | 71.92 | 27.41 | 34.94 | 5.66 | 15786.9 | 313.02 | 40.60 |
| BR-18 | 21 | 31.80 | 5675.8 | 4.992 | 955.3 | 1011.0 | 776.5 | 16.27 | 983.53 | 5717.8 | 7974.8 | 2346.7 | 217.34 | 79.52 | 27.71 | 37.38 | 5.30 | 16039.3 | 324.57 | 42.68 |
| BR-19 | 2 | 1.55 | 750.6 | 1.559 | 3776.5 | 333.7 | 697.1 | 30.98 | 1496.55 | 5161.3 | 7306.5 | 2058.1 | 293.87 | 104.00 | 35.95 | 24.06 | 4.36 | 14525.9 | 433.82 | 28.42 |
| BR-20 | 2 | 1.85 | 535.1 | 1.853 | 1575.4 | 688.1 | 720.8 | 13.64 | 779.54 | 2083.2 | 3532.4 | 1497.3 | 266.81 | 82.24 | 20.83 | 38.77 | 5.58 | 7112.9 | 369.88 | 44.35 |
| BR-21 | 14 | 29.80 | 10851.6 | 6.173 | 1635.4 | 1039.9 | 616.5 | 43.43 | 730.59 | 9074.7 | 12269.8 | 3128.9 | 251.51 | 76.46 | 21.31 | 30.69 | 5.17 | 24473.4 | 349.28 | 35.86 |
| BR-22 | 2 | 0.50 | 885.2 | 3.612 | 594.8 | 336.8 | 434.0 | 69.06 | 698.80 | 3100.0 | 5700.0 | 2000.0 | 212.20 | 56.00 | 17.22 | 27.08 | 4.12 | 10800.0 | 285.42 | 31.20 |
| BR-23 | 1 | 0.30 | 608.0 | 2.660 | 733.0 | 500.0 | 1000.0 | 86.50 | 850.00 | 2800.0 | 4500.0 | 1700.0 | 271.00 | 88.90 | 40.60 | 45.90 | 7.00 | 9000.0 | 446.4 | 52.90 |
| BR-24 | 25 | 50.50 | 6210.3 | 4.721 | 1618.6 | 1241.8 | 465.2 | 37.98 | 621.76 | 8113.3 | 9760.0 | 2496.2 | 195.14 | 55.00 | 13.73 | 21.84 | 4.17 | 20369.5 | 263.87 | 26.01 |
| BR-25 | 2 | 0.55 | 668.6 | 1.670 | 1358.6 | 309.1 | 563.6 | 18.52 | 1137.45 | 1200.0 | 4063.6 | 2390.9 | 286.73 | 85.04 | 21.75 | 24.39 | 3.69 | 7654.5 | 393.52 | 27.60 |
| BR-26 | 2 | 0.35 | 567.9 | 1.539 | 392.6 | 564.3 | 430.0 | 10.80 | 773.86 | 2042.9 | 4271.4 | 1328.6 | 163.43 | 44.00 | 13.93 | 24.04 | 3.56 | 7642.9 | 221.36 | 27.60 |
| BR-27 | 11 | 25.90 | 4684.3 | 4.983 | 1030.7 | 1272.7 | 631.5 | 51.07 | 934.71 | 8418.9 | 9543.2 | 2451.7 | 215.56 | 79.05 | 19.04 | 24.00 | 4.44 | 20413.8 | 313.65 | 28.44 |
| Total | 162 | 359.90 | 5752.7 | 4.161 | 2241.7 | 952.1 | 608.1 | 40.63 | 826.16 | 6752 | 8800 | 2360 | 215.43 | 75.00 | 21.65 | 26.90 | 4.52 | 17912.0 | 312.08 | 31.42 |

Fig. II–1–7 Vertical Variation of Elements, BRL–2 and BRL–3

BR-17(50.20m)




BR-24(50.50m)

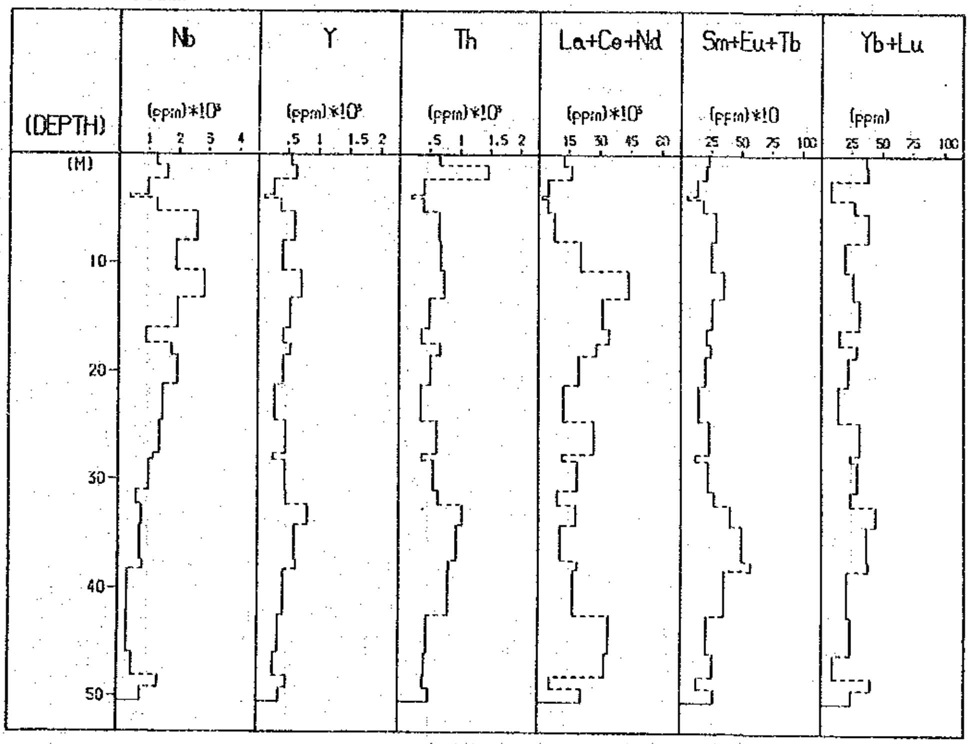
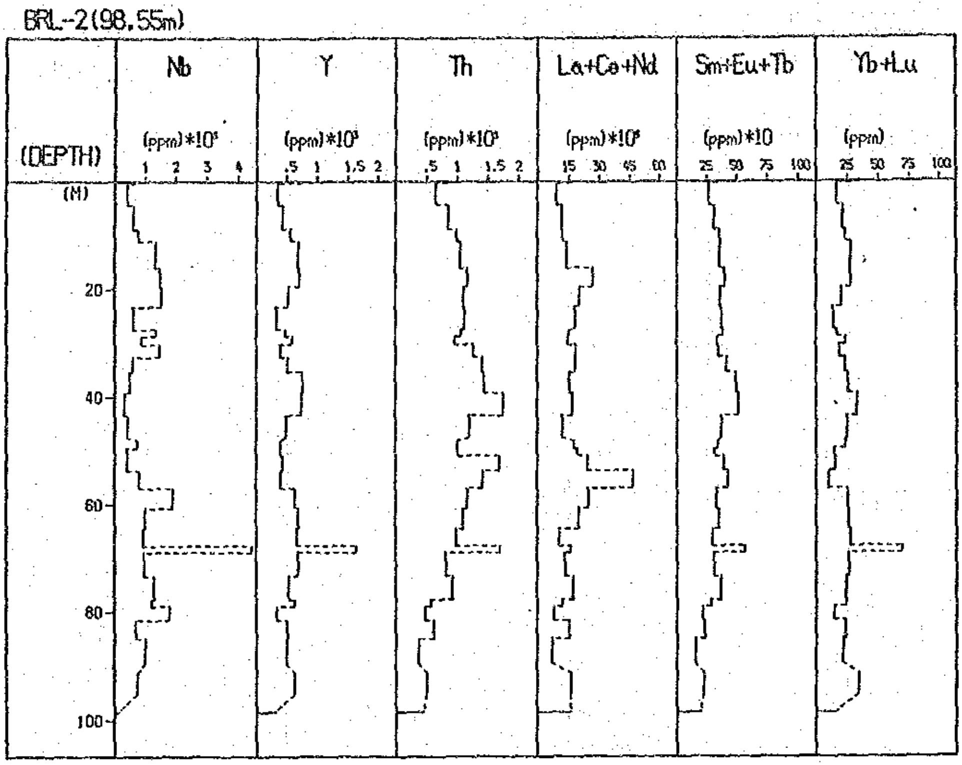
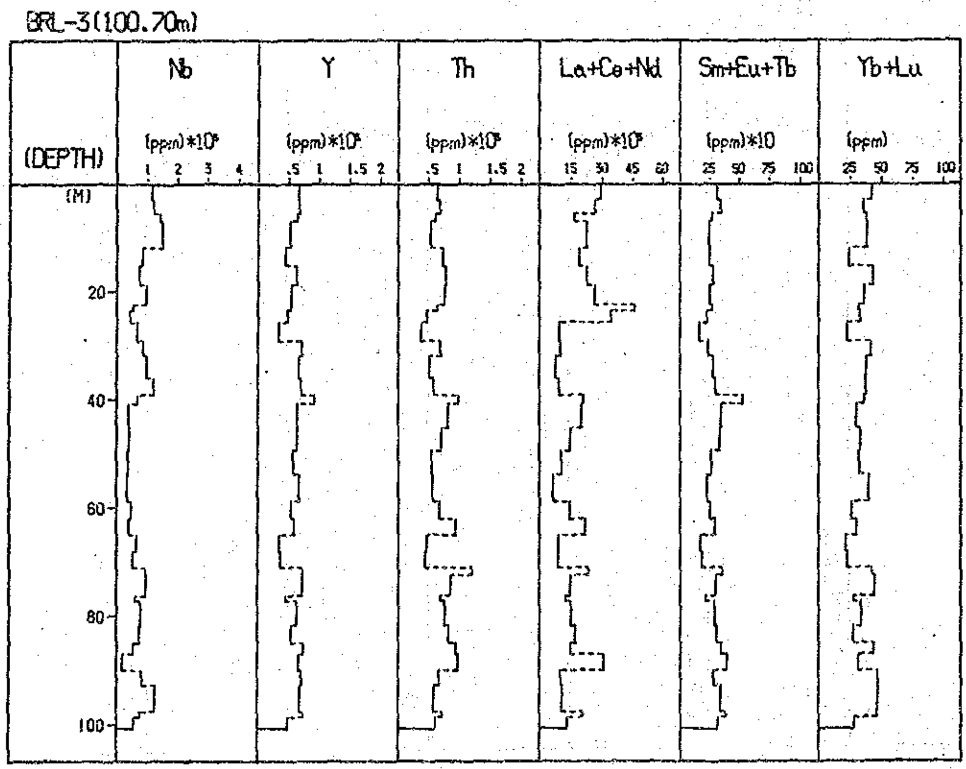


Fig. II–1–8 Vertical Variation of Elements, BR–17 and BR–24



It also sufficiently coincides with the mineraliogical results on drill cores of Hole BRL-1 by the second-year work.

### 1-4-4 Ore reserves estimation

The geological ore reserves of REE ore, associated with the carbonatite body in Buru Hill, were estimated based on the results of geological research and ore grade estimations of the elements by diamond drill cores, in accordance with the estimations of three-dimensional configuration of the ore body on east-west directional cross sections, Figs. II -1-9 to II -1-12.

Ore grade grouping were established by paying a remark on the content of La + Ce + Nd, the grade of which was determined by the high-accuracy analysis techniques on a more chemically reliable order of Ore Grade Level - percentage unit - , meanwhile, the remaining elements were chemically analysed on the order of Geochemistry Level - parts per million unit - with less reliability than the former.

It is estimated by the examinations of grade distribution on the east-west directional cross sections that the high grade ore zone is observed in upper portion of the carbonatite body, demarcated by the ground water table on 1,295 metres high above sea level, which is however variable in each drill hole, and is considered that an elucidation of zonal distribution of ore grade in the carbonatite body is uneasy due to a showing of irregular grade distribution in both of upper and lower portions of the body. The contents of REE and Nb in the reduction zone in lower part of the carbonatite body are low, what is estimated to be less economical (Fig. II -1-13).

The current estimation of the geological are reserves on the Buru Hill carbonatite, therefore, limitedly includes the ore blocks in the oxydation zone, meanwhile, the block occupied by unweathered carbonatite is omitted from the estimation.

The measurement of specific gravity value of the carbonatite was not made by the current work, however, the value of 1.70 was empirically applied for the estimation. It is mainly based on the porous character of rock in oxydized zone and also on wide-spread occurrences of cavities observed in drill cores of carbonatite body.

Table II -1-8 shows the weighted average values of elements in weathered zone, Table II -1-9 shows that in fresh zone and Table II -1-10 shows the results of ore reserves estimation.

## 1-5 Results of Petrological and Mineralogical Examinations

Microscopic examinations of rock samples by thin sections, those of ore samples by polished thin sections, whole rock chemical analyses, mineralogical identifications by electron probe microanalyzer, absolute age determinations of rocks by potash-argon method, chemical analyses of ore minerals and mineral size distribution tests, and measurements of oxygen isotope ratio for the drill core samples were implemented by the current work. Locations of samples for the current tests are shown in Apx. 1.

## LEGEND

| Nb (ppm) | Th (ppm) | Y (ppm) | L<br>La+Ce+Nd (ppm) | M<br>Sm+Eu+Tb (ppm) | H<br>Yb+Lu (ppm) |
|---|---|---|---|---|---|
| Above 1800 | Above 1800 | Above 1300 | Above 36000 | Above 540 | Above 50 |
| 1600 - 1800 | 1600 - 1800 | 1050 - 1300 | 32000 - 36000 | 480 - 540 | 45 - 50 |
| 1400 - 1600 | 1400 - 1600 | 900 - 1050 | 28000 - 32000 | 420 - 480 | 40 - 45 |
| 1200 - 1400 | 1200 - 1400 | 750 - 900 | 24000 - 28000 | 360 - 420 | 35 - 40 |
| 1000 - 1200 | 1000 - 1200 | 600 - 750 | 20000 - 24000 | 300 - 360 | 30 - 35 |
| 800 - 1000 | 800 - 1000 | 450 - 600 | 16000 - 20000 | 240 - 300 | 25 - 30 |
| 600 - 800 | 600 - 800 | 300 - 450 | 12000 - 16000 | 180 - 240 | 20 - 25 |
| 400 - 600 | 400 - 600 | 150 - 300 | 8000 - 12000 | 120 - 180 | 15 - 20 |
| Below 400 | Below 400 | Below 150 | Below 8000 | Below 120 | Below 15 |

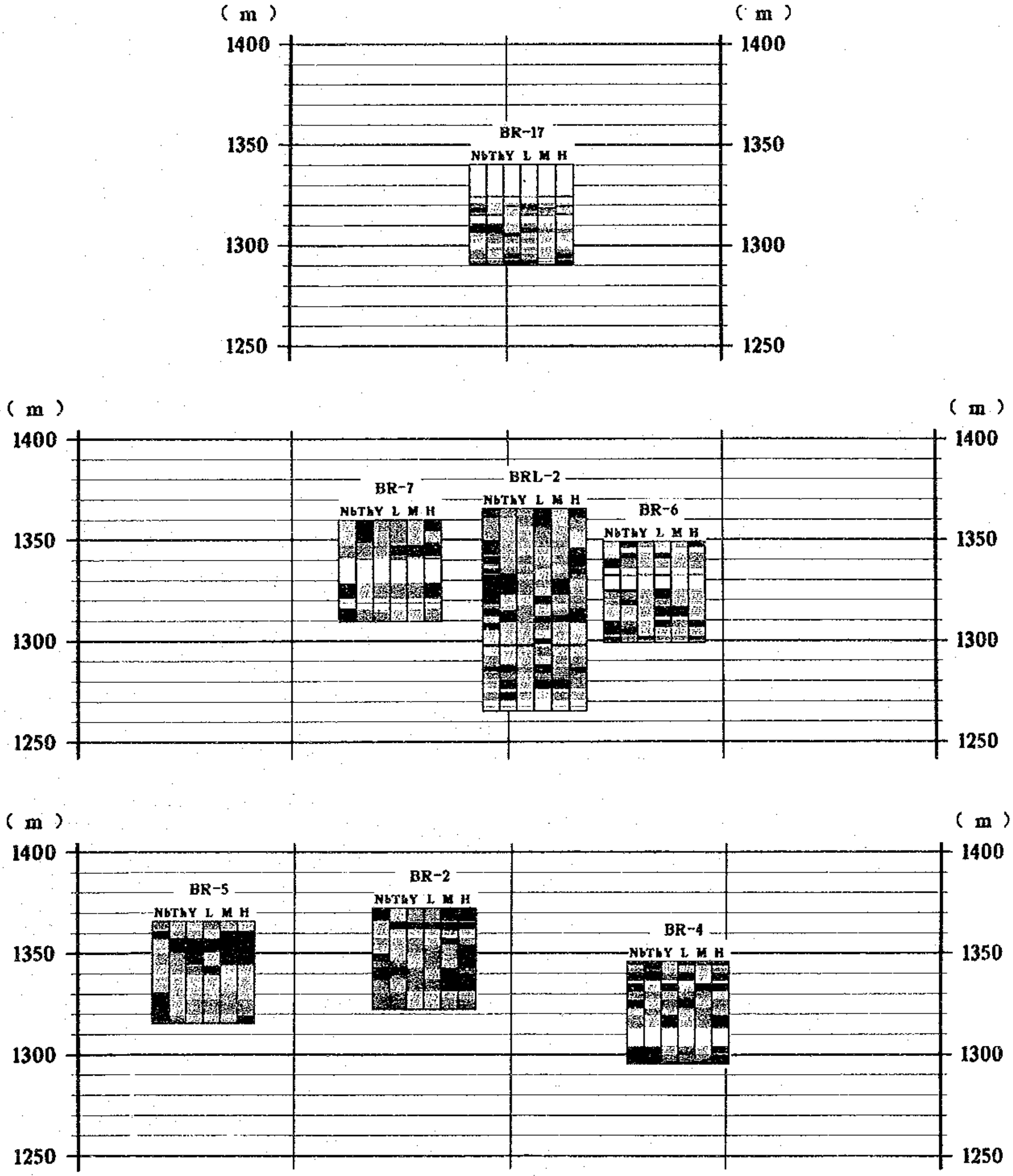
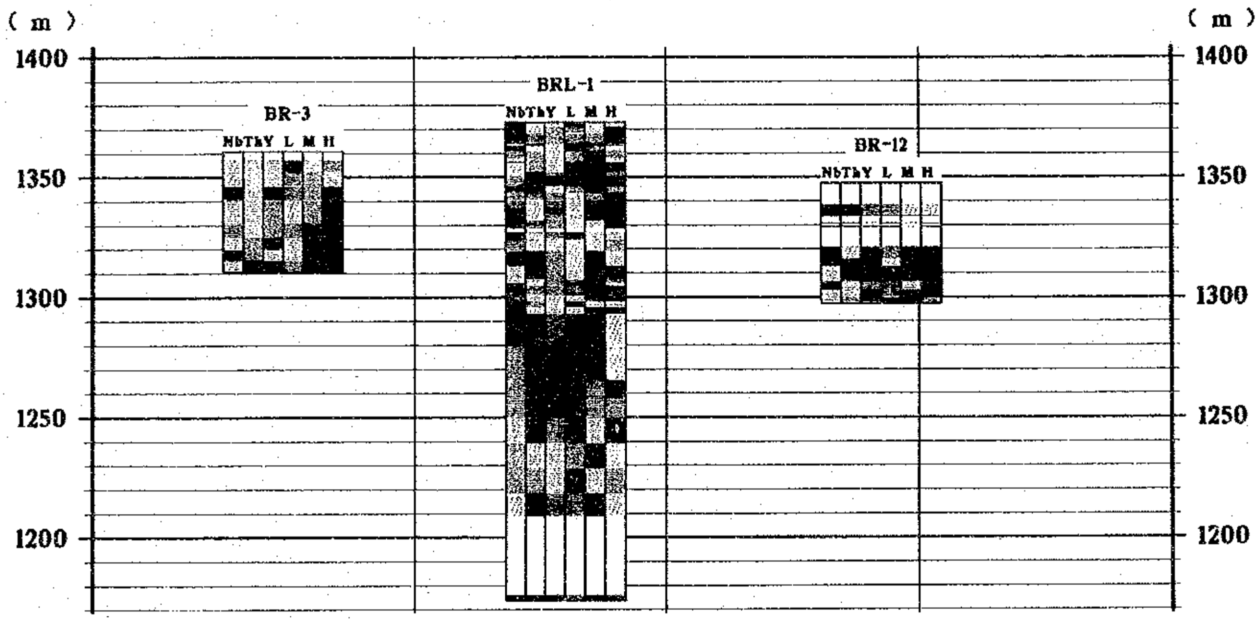



Fig. II–1–9 Assay Cross Sections, E–W – (1)

## LEGEND

| Nb (ppm) | | Th (ppm) | | Y (ppm) | | L<br>La+Ce+Nd (ppm) | | M<br>Sm+Eu+Tb (ppm) | | H<br>Yb+Lu (ppm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Above | 1800 | Above | 1800 | Above | 1300 | Above | 36000 | Above | 540 | Above | 50 |
| 1600 ~ | 1800 | 1600 ~ | 1800 | 1050 ~ | 1300 | 32000 ~ | 36000 | 480 ~ | 540 | 45 ~ | 50 |
| 1400 ~ | 1600 | 1400 ~ | 1600 | 900 ~ | 1050 | 28000 ~ | 32000 | 420 ~ | 480 | 40 ~ | 45 |
| 1200 ~ | 1400 | 1200 ~ | 1400 | 750 ~ | 900 | 24000 ~ | 28000 | 360 ~ | 420 | 35 ~ | 40 |
| 1000 ~ | 1200 | 1000 ~ | 1200 | 600 ~ | 750 | 20000 ~ | 24000 | 300 ~ | 360 | 30 ~ | 35 |
| 800 ~ | 1000 | 800 ~ | 1000 | 450 ~ | 600 | 16000 ~ | 20000 | 240 ~ | 300 | 25 ~ | 30 |
| 600 ~ | 800 | 600 ~ | 800 | 300 ~ | 450 | 12000 ~ | 16000 | 180 ~ | 240 | 20 ~ | 25 |
| 400 ~ | 600 | 400 ~ | 600 | 150 ~ | 300 | 8000 ~ | 12000 | 120 ~ | 180 | 15 ~ | 20 |
| Below | 400 | Below | 400 | Below | 150 | Below | 8000 | Below | 120 | Below | 15 |



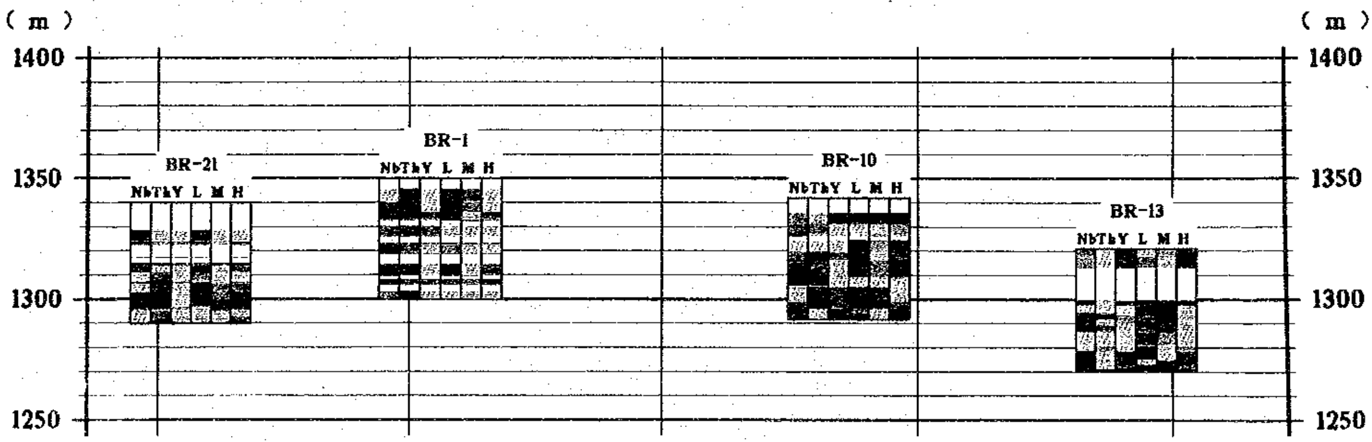




Fig. II–1–10 Assay Cross Sections, E–W – (2)

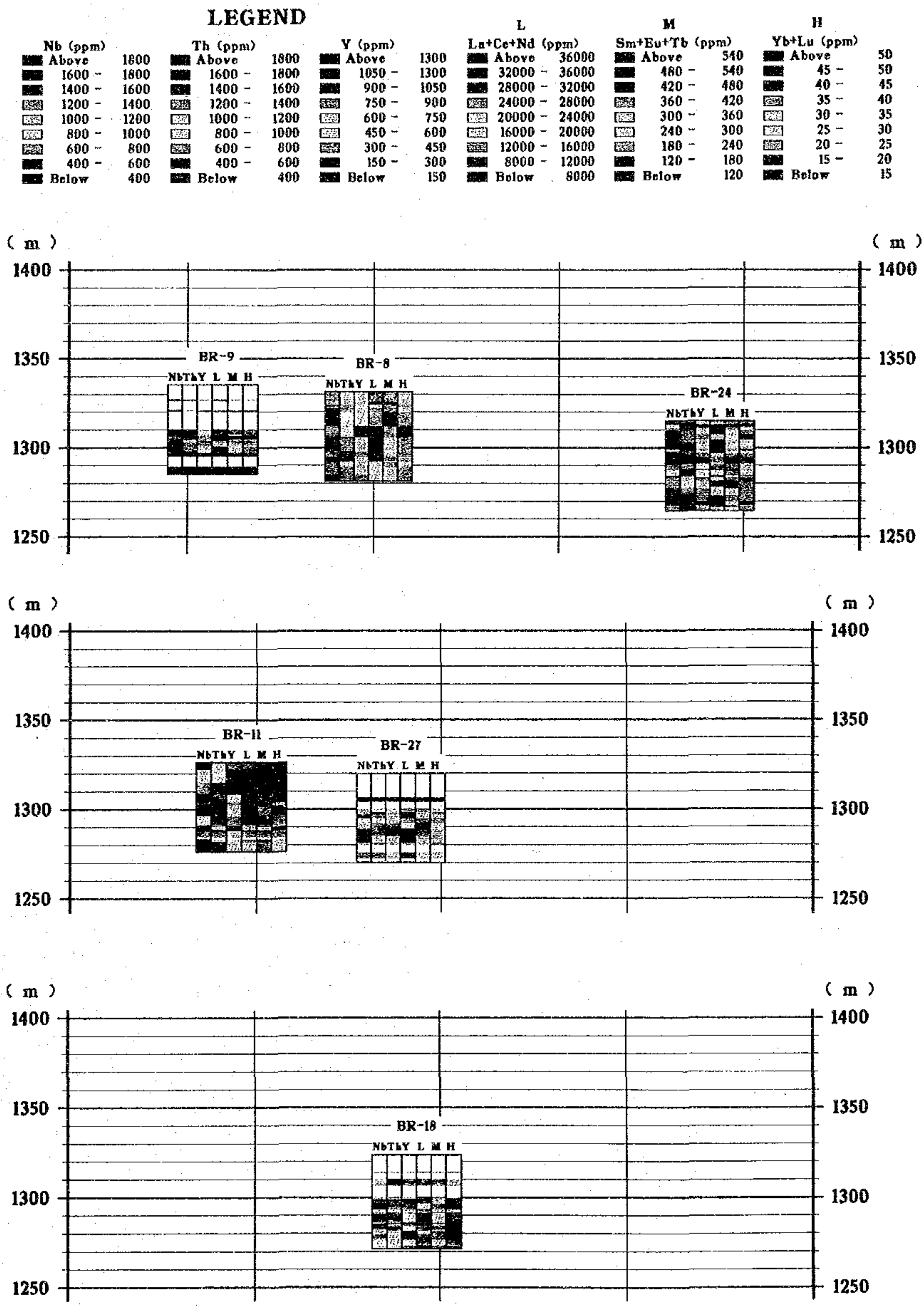



Fig. II–1–11 Assay Cross Sections, E–W – (3)

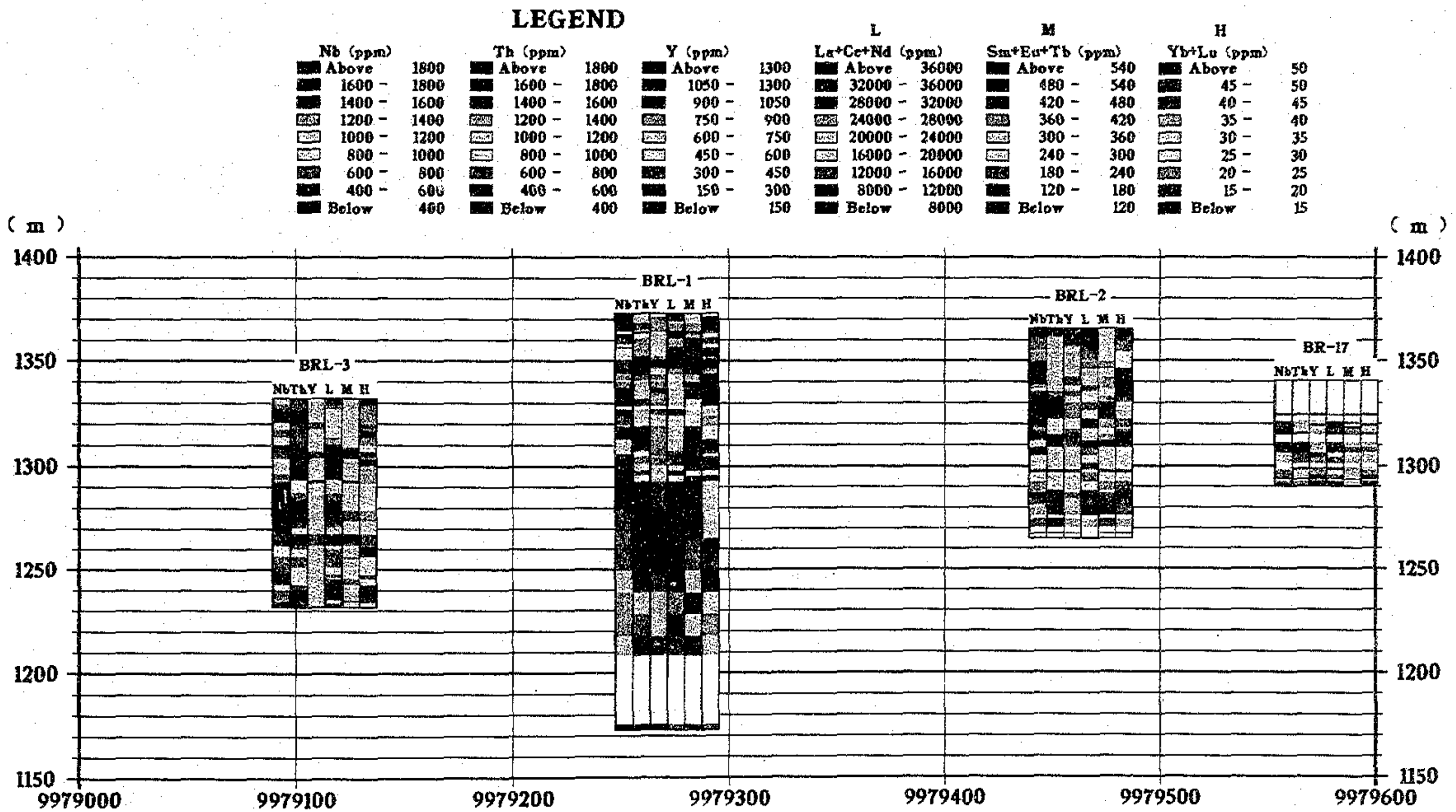



Fig. II-1-12 Assay Cross Sections, N-S

Table II–1–8 Average Value of Elements, Weathered Zone

| Component | Unit | No. of sample | Maximum | Minimum | Mean(m) | Total length Analyzed(m) |
|---|---|---|---|---|---|---|
| BA | PPM | 228 | 126000 | 5700 | 44906.0 | 676.90 |
| SR | PPM | 228 | 7780 | 226 | 1654.3 | 676.90 |
| NB | PPM | 228 | 4950 | 70 | 1037.7 | 676.90 |
| Y | PPM | 228 | 1950 | 105 | 724.6 | 676.90 |
| U | PPM | 228 | 429 | 1 | 48.6 | 676.90 |
| TH | PPM | 228 | 2084 | 81 | 918.7 | 676.90 |
| LA | PPM | 228 | 23100 | 400 | 7959.0 | 676.90 |
| CE | PPM | 228 | 24400 | 1000 | 10043.7 | 676.90 |
| ND | PPM | 228 | 8000 | 300 | 2716.4 | 676.90 |
| SM | PPM | 228 | 494.0 | 42.0 | 267.05 | 676.90 |
| EU | PPM | 228 | 198.0 | 10.9 | 80.19 | 676.90 |
| TB | PPM | 228 | 77.6 | 2.6 | 27.22 | 676.90 |
| YB | PPM | 228 | 82.1 | 4.8 | 32.88 | 676.90 |
| LU | PPM | 228 | 16.5 | 1.1 | 5.21 | 676.90 |

Table II–1–9 Average Value of Elements, Fresh Zone

| Component | Unit | No. of sample | Maximum | Minimum | Mean(m) | Total length Analyzed(m) |
|---|---|---|---|---|---|---|
| BA | PPM | 89 | 90600 | 4800 | 33800.1 | 316.50 |
| SR | PPM | 89 | 29600 | 850 | 2932.8 | 316.50 |
| NB | PPM | 89 | 3100 | 125 | 810.0 | 316.50 |
| Y | PPM | 89 | 980 | 225 | 521.5 | 316.50 |
| U | PPM | 89 | 124 | 1 | 13.8 | 316.50 |
| TH | PPM | 89 | 1545 | 225 | 618.5 | 316.50 |
| LA | PPM | 89 | 22600 | 690 | 5601.4 | 316.50 |
| CE | PPM | 89 | 20400 | 1900 | 7282.0 | 316.50 |
| ND | PPM | 89 | 6200 | 500 | 2152.0 | 316.50 |
| SM | PPM | 89 | 633.5 | 83.3 | 210.97 | 316.50 |
| EU | PPM | 89 | 169.4 | 23.5 | 61.16 | 316.50 |
| TB | PPM | 89 | 38.2 | 3.2 | 18.09 | 316.50 |
| YB | PPM | 89 | 41.8 | 6.3 | 25.42 | 316.50 |
| LU | PPM | 89 | 6.7 | 1.5 | 4.04 | 316.50 |

Table II–1–10 Ore Reserves and Grade of the Buru Hill Deposit

| Reserves (Ton) | | La (%) | Ce (%) | Pr*1 (%) | Nd (%) | Sm (ppm) | Eu (ppm) | Tb (ppm) | Yb (ppm) | Lu (ppm) | Y (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crude Ore | 10,700,000 | 0.796 | 1.004 | 0.09 | 0.272 | 261 | 80 | 27 | 33 | 5.2 | 724 |
| $TRe_2O_3$ | 280,000 | 0.931 | 1.235*2 | 0.107 | 0.318 | 310 | 93 | 31 | 38 | 6.0 | 919 |
| | | 2.59 % | | | | 478 ppm | | | | | 919 |
| Total $Re_2O_3$ grade | | 2.63 % | | | | | | | | | |

Other elements : $Nb_2O_5$ : 0.14 %
$P_2O_5$ : 1.32 %

*1 : Estimated value from average content in bastnäsite

*2 : $CeO_2$ ,

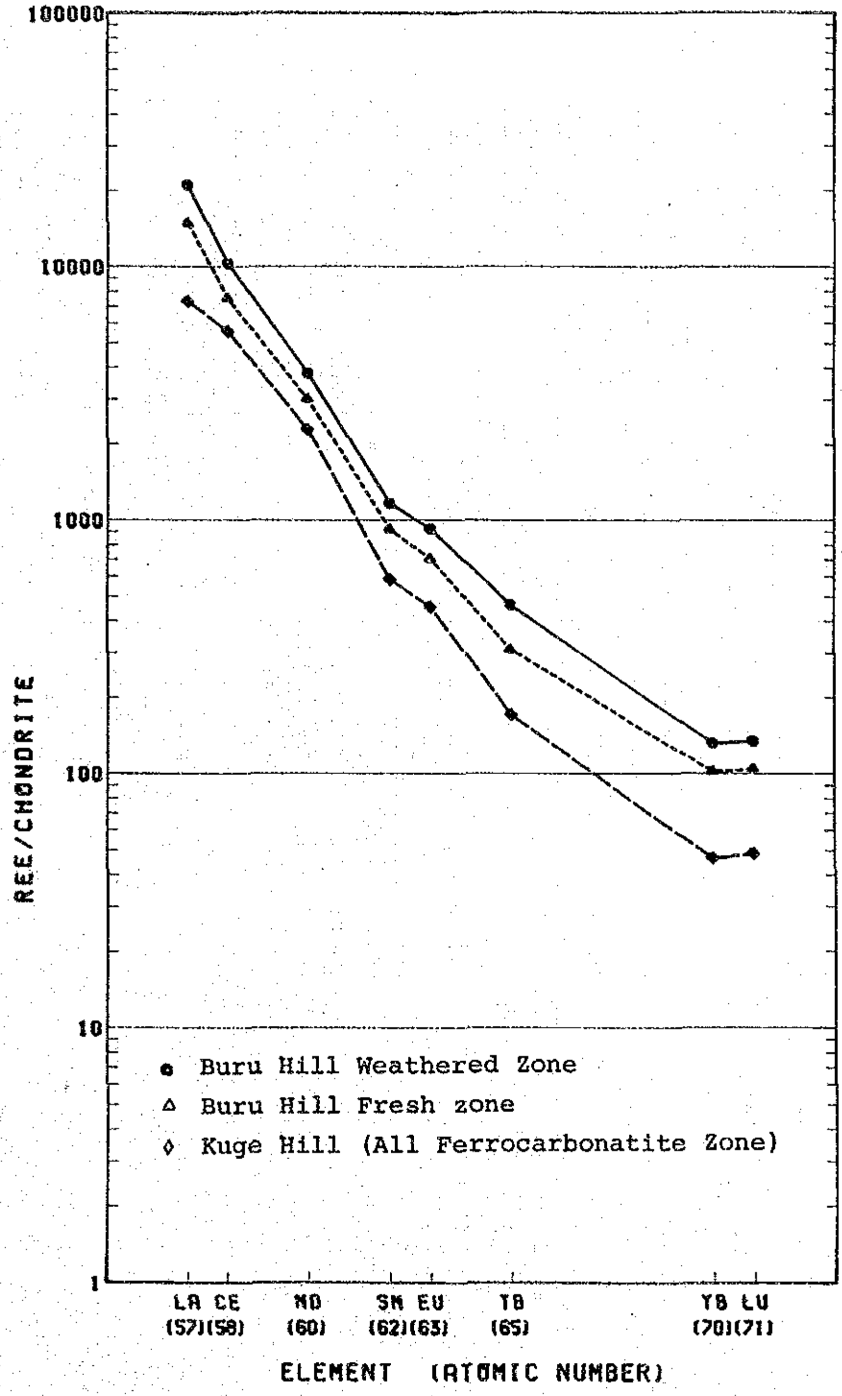



Fig. II–1–13 Chondrite Normalized Patterns of Carbonatites in the Buru Hill

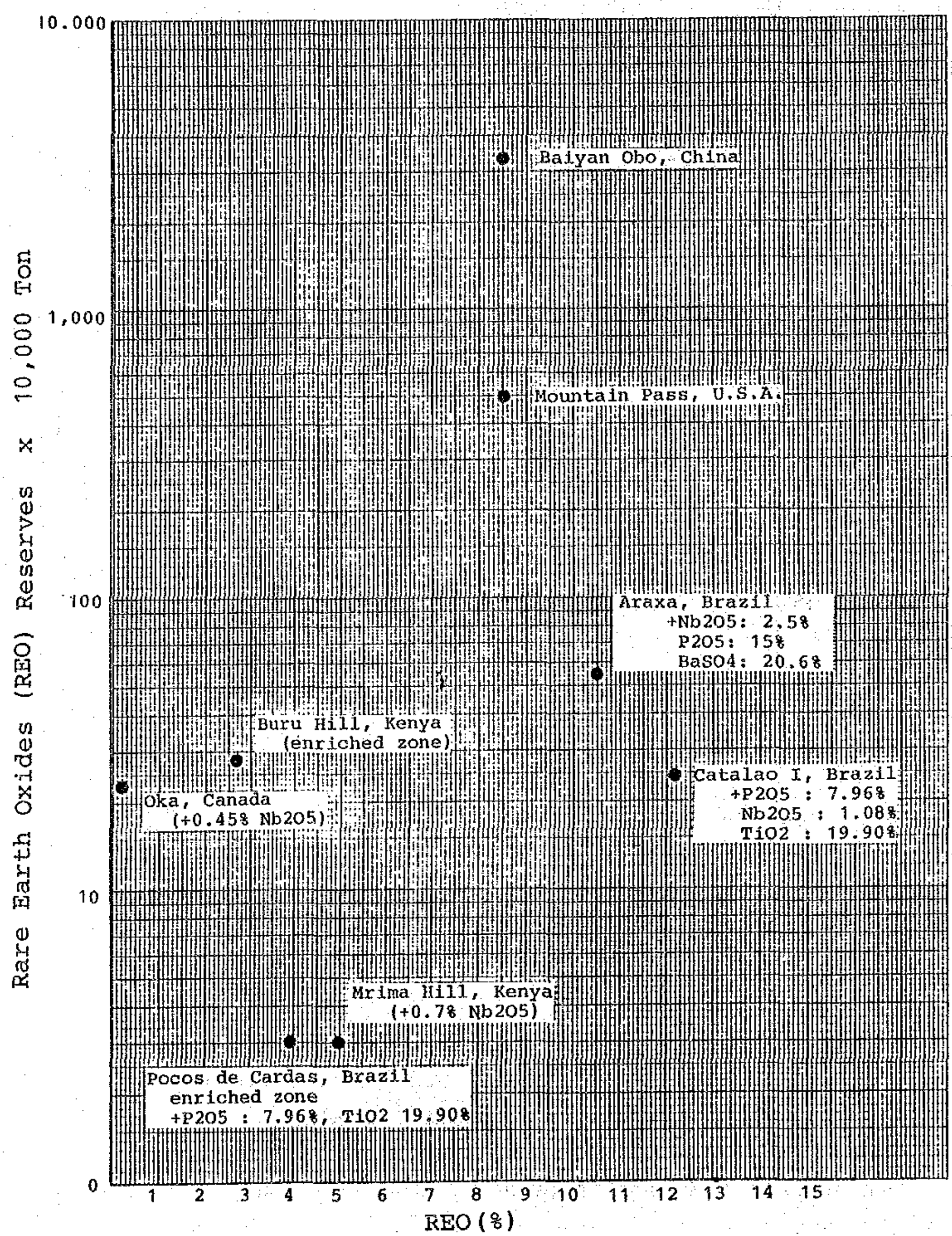



*Fig. II–1–14 Grade-Reserve Plots of World Rare Earth Deposits*

### 1-5-1 Microscopic examinations of rock by thin sections

Twelve (12) samples in the area were microscopically examined. Details of the examination results on carbonititic rocks have already been reported in the course of the previous first- and second-year works, consequently, examinations on gneiss samples, which are intruded by carbonatite or are fractured by carbonatite intrusion, were emphasizedly carried out by the current work, as summarized in Apxs. 3 to 4.

(1) Granitoid gneiss and amphibole gneiss

Granitoid gneiss is composed of plagioclase and potash feldspar, 1 to 2 millimetres long, in a form of remnant minerals (porphyroclasts) after fine-fracturing, and of a groundmass, composed of finely fractured potash feldspar, plagioclase and quartz. Sericite is observed in a form of a circumscription of the porphyroclasts the above. It is obviously granite-originated.

Amphibole gneiss is composed of acicular phenocrysts of amphibole, possibly of actinolite-tremolite series, with parallel associations with anhedral to subhedral plagioclase. Euhedral phenocrysts of epidote and biotite are also observed.

(2) Fractured gneiss

Intense brecciation or fracturing of gneiss caused by an intrusion of carbonatite, located in adjacent portions of the upper-most (subsurface body in southern Buru Hill) or marginal (main Buru Hill Body) zones of the intrusive carbonatite body, are observed. Finely fractured granitoid gneiss usually shows a structure that carries a matrix cemented by i) carbonate minerals, ii) iron oxide minerals, mainly composed of goethite and hematite and by iii) both of above two. The southern Bull Hill Body is cemented by only iron oxide minerals, meanwhile, by three materials the above in the occasion of the Main Buru Hill Body.

(3) Carbonatite

Alvikitic dyke of the latest stage, sample - numbered BR-20-B, observed in the vicinity of carbonatite body, shows a saccharoidal microcrystalline texture, associated with a small quantity of epidote and opaque minerals.

Carbonatite, sample-numbered BRL-1-I, prepared for the potash-argon age determination test, carries a relatively large quantity of fine and euhedral biotite, which has been sent to the age determination test after a mineralogical separation.

(4) Phonolite

A laminated valcanic rock, white and fine-grained, is observed at the lower-most of the drill hole BRL-2. The rock is microscopically identified as phonolitic tuff or welded tuff.

### 1-5-2 Microscopic examinations of ore by polished thin sections

Fifteen (15) samples in the area were microscopically examined. Results of the examinations are tabulated in Apx. 5 and general notes of the examinations are shown in Apx. 6.

(1) Carbonatite

Carbonate minerals in carbonatite mainly consist of calcite, associated with siderite. A minor quantity of silicate minerals is generally contained. The identification of bastnaésite, that is a REE mineral, is generally difficult, caused by that bastnaésite commonly shows a very fine crystalline form or an aggregate form of the above crystals. Opaque minerals mainly consist of goethite, hematite and lepidochrocite. The most of these minerals are considered to have been changed from magnetite. Pyrite, marcasite, galena, partially electrum, are observed in carbonatite in the area of drill sites BRL-1, BRL-3 and BR-24.

(2) Iron-manganese ore

Manganese minerals are abanduntly observed with iron minerals. Pyrolusite, psilomelane, manganite are identified by a collaborative X-ray power diffractometry. Pyrolusite is to be of a secondary mineral as a weathered product.

### 1-5-3 Whole rock chemical analysis

Whole rock chemical analyses on ten (10) samples in the area were implemented by the current work. The analyses of weathered rocks were mainly carried out, because of that the analyses of fresh carbonatite rocks have been sufficiently implemented by the previous works, first- and second-year. Results of the analyses are shown in Apx. 7.

(1) Lateritized carbonatite

It shows 44.26 percent of $Fe_2O_3$ and 17.02 percent of CaO, respectively. In comparison with an average content value of these elements in the fresh carbonatite by the previous work, refer Report on Phase II, that shows 17.78 percent of $Fe_2O_3$ and 32.50 percent of CaO, respectively, it shows 2.5 times of $Fe_2O_3$ and 0.52 time of CaO contents, by what an implication of a leaching effect of carbonate minerals and a supergene enrichment of iron minerals is remarkably conducted.

(2) Weathered ferrocarbonatite

It shows 47 percent of $Fe_2O_3$ and 7.6 percent of CaO in average, respectively. It carries 1.4 times of $Fe_2O_3$ and 0.38 time of CaO contents in comparison with an average value of those elements in the fresh carbonatite, by what a similar implication to the above, in the occasion of weathered carbonatite, is also conducted.

(3) Weathered manganese-iron ore

It shows 60 percent of $Fe_2O_3$ approximately, 3.7 percent of CaO and 13 percent of MnO in average, respectively. These show a negligible difference between weathered and fresh ore samples. However, a decrease in content of FeO is observed as same as in the occasions of carbonatite and ferrocarbonatite.

(4) Weathered brecciated gneiss

Brecciated or fractured gneiss, located in directly overlying portion of the subsurface southern Buru Hill carbonatite has an intersertal textural matrix, cemented by ferruginous materials.

Gneiss carries 26.4 percent of $Fe_2O_3$, 2.9 percent of MnO, 2.9 percent of BaO in average, respectively, to be totaled to 32.2 percent. The 42.5 percent of $SiO_2$ content in average is further added, then, a grand total of the elements, the above, is made to be of 74.7 percent, which corresponds to an average content value of the above elements in typical granitoid rock in the area. It may provide an implication that the materials, which occupies a one third of the total weight of granitoid rock might be derived from carbonatite.

(5) Brecciated fresh carbonatite, rich in chlorite

The rock carries a more content of $SiO_2$, MgO, $Na_2O$ and $K_2O$ than that in typical, massive and homogeneous carbonatite. Brecciated fresh carbonatite, prepared to the current test, has never been subjected to any geological weathering, by what it is inferred that the brecciation has been caused by an intrusion of the residual materials, rich in silicate mineral components, concentrated at the latest stage of carbonatite intrusion.

### 1-5-4 Mineral identifications and determinations of mineral components by electron probe microanalyzer

Determinations of mineral components and quantitative chemical analyses for the six (6) drill core samples were implemented by the current work. Outlined features of samples and mineral components are shown in Apx. 8, results of the quantitative chemical analyses of minerals are in Apx. 9, and SEM images are in Apx. 10, respectively.

(1) Mineral components

Carbonatite mainly consists of calcite and manganese-rich-siderite, associated with siderite and ankerite. It is accessorily associated with barite, hematite, goethite, apatite, fluorite, etc. A very small quantity of pyrochlore, phlogopite, rancieite (partly rich in barium), bastnaésite, etc. is also associated. A sample for the test carries pyrite and sphalerite, an another sample contains galena.

Ferrocarbonatite carries similar minerals to those of carbonatite. However, a larger quantity of iron minerals, such as goethite and hematite, than that of carbonate minerals, is contained.

(2) Quantitative chemical analysis of mineral component

Quantitative chemical analysis: Determinations of chemical components of twenty-one (21) mineral grains of five (5) species, i.e., bastnaésite, a major REE mineral in the Buru Hill ore, pyrochlore as a Nb-bearing mineral, rancieite as a major manganese mineral, barite abundantly associated with various type of ore and a carbonate mineral rich in REE, were implemented by the current work.

Every measurement for each mineral grain was carried out on different three (3) spots on each individual grain surface.

Chemical components of the minerals and compositional features are shown below:

Bastnaésite: Composed of aggregates of very fine acicular crystals or of radial distributions. Two types of grain were identified; one is rich in La and Ce, and poor in Nd, and another one is inversely rich in Nd and poor in La, respectively. The $La_2O_3$ + $CeO_2$ + $Nd_2O_3$ content widely ranges from 46 percent to 56 percent, what is inferred to be under the effects of background, due to an acicular occurrence of the grain.

Pyrochlore: Observed as a euhedral crystal, hexagonal and relatively coarse-grained. The content is relatively constant, 65 percent to 67 percent of $Nb_2O_5$, 7 percent to 10 percent of $Ta_2O_5$ and 2 percent to 4 percent of $TiO_2$.

Rancieite: Observed showing an intergranular irregular occurrence adjacent to other minerals. Carries 55 percent to 59 percent of MnO, 15 percent to 16 percent of BaO and 2 percent to 4 percent of FeO. Considered to be of a species, compositionally invariable and of barium-bearing.

Barite: Mainly shows crystals, coarse-grained and euhedral. The total of BaO and $SO_3$ contents makes upto 99 percent of the whole. Considered to be with little impurity and compositionally invariable.

Carbonate mineral rich in REE: Observed in a form of aggregates of fine-grained acicular crystals. One sample was tested. Carries 24 percent of MnO, 25 percent of $CeO_2$ + $La_2O_3$ + $Nd_2O_3$, as the main components, associated with 8 percent of CaO, 5 percent of BaO, 2 percent of $Fe_2O_3$, etc. The mineral name of the specimen is not fixed up yet.

### 1-5-5 Absolute age determination by potash-argon method

An occurrence of fresh carbonatite body with fine-grained biotite is observed at the depth of ca. 148 metres of Diamond Drill Hole BRL-1, completed by the second-year programme. One sample of the above carbonatite body was tested to determine the absolute geological age of the Buru Hill Carbonatite and to provide a comparison of the age with that of other carbonatite body observed in different area, i.e., in Homa Bay Area, in where age determination results are sufficiently available by the previous works.

| Sample number | Tested mineral | Radiometric age, Ma | $^{40}$Ar [scc/gm × $10^{-5}$] | %$^{40}$Ar | %K |
|---|---|---|---|---|---|
| BRL-1-I | Biotite | 22.2 ± 1.1 | 0.537 | 40.4 | 6.10 |
| | | | 0.526 | 47.0 | 6.08 |
| | | | 0.525 | 61.6 | |

The radiometric age value of 22.2±1.1 Ma, obtained by the current determination test, corresponds to the early Miocene age.

The radiometric age values of the different carbonatite bodies by the previous research in Homa Bay Area are reported as follows:

| | | | | |
|---|---|---|---|---|
| Rangwa | : | The main activity | ; | Later than 11 Ma |
| | | Activity of early sövite | ; | Earlier than 19.6 Ma |
| Wasaki Peninsula | : | 12 to 16 Ma | | |
| Ruri Hill | : | 5.5 to 7.7 Ma | | |
| Homa Mountain | : | 2.9 to 12.0 Ma | | |

(all the above by LeBas, 1977).

It is, therefore, concluded that the stage of the intrusive activity of Buru Hill carbonatite is the earliest in Homa Bay area, other than that of early stage in Rangwa.

The potash-argon dating value of melanephelinite, which covers the Legetet Hill carbonatite, was determined by the 1st-year work 1987 to be of 10.7 Ma. The intrusive activities of adjacent Legetet Hill and Buru Hill carbonatites are estimated to be enhanced on the stage prior to the volcanic activity of Tindred Mountain, which was determined by Pickford et al. (1981) to be of 5.6 to 9.9 Ma.

### 1-5-6 Chemical analysis of ore minerals and measurement of grain size distribution

(1) Outline

Five types of ore, associated with the Buru Hill carbonatite,i.e., carbonatite, ferrocarbonatite, siliceous ore, calcareous-ferruginous ore and manganiferrous ore, were gravitationally separated to determine a grain size of bastnaésite and to carry out a chemical analysis of ore minerals.

Heavy minerals were gravitationally separated by the process that the ores were pulverized to the size less than 60 meshes to be treated by 10 percent-diluted hydrochloric acid for a remove of soluble carbonate minerals, followed by a repetition of panning processing of residues. The practical process, the above, poses a difficulty to produce a monomineral separate, caused by the approximate values of specific gravity among the above minerals, i.e., 5.2 of magnetite, 5.26 of hematite, 4.50 of barite, 4.28 of goethite and 5.2 of bastnaésite. Particularly, bastnaésite usually shows an occurrence in a form of aggregate of very fine-grained acicular crystals, what poses a difficulty of monomineralic separation. The end-product by the above process is of an aggregate of heavy minerals. Grain size measurement was made under the microscope by a preparation of thin section of the fine-grained end-product, the above.

(2) Results of grain size measurement and chemical analysis

The results of grain size measurement are shown in Apx. 11 and of chemical analysis are in Apx. 12.

Under the microscope, bastnaésite shows a nearly similar occurrence to that of the other types of ores, and is very fine-grained, 0.5 millimetre long in maximum, mostly less than 0.1 millimeter. It is generally observed that grain size of carbonatite is larger than the other types of ore. The general smallness of grain size of ore minerals in Buru Hill carbonatite may pose possible hard lines of mineral processing technology.

Based on the results of mineral separation process and chemical analysis, it is estimated that bastnaésite is hardly monomineral-separated by a gravitational process properly and that an application of a combined process of floatation, static electricity, electromagnetism technologies and etc. should be required to produce a sufficient quantity of bastnaésite concentrate for an establishment of successful metallurgical test.

### 1-5-7 Measurement of oxygen isotope ratio

(1) Objective and outline of samples

Measurements of the oxygen isotope ratio on carbonititic rocks in Buru Hill area were carried out by the current work to estimate the depth, on which the intrusive carbonatite, body was consolidated, and the relative location of the body on geological vertical section. Ten (10) samples, composed of five of unweathered carbonititic rock, one of weathered carbonatite, one of carbonate-mineralized nephelinite, one of calcite formed in a cavity of weathered carbonatite and two of basement gneiss adjacent to the carbonatite body, were determined for the measurements of oxygen isotope ratio.

(2) Measurement results and interpretations

The results of the measurements of oxygen isotope ratio are listed in Table II-1-11.

The values of $\delta^{18}O$ of unweathered carbonatite, unweathered ferrocarbonatite, siliceous iron ore and carbonate-mineralized nephelinite are in the range of 10.1 per mill to 13.7 per mill, 11.2 per mill average. These values are approximate to those of carbonatite in eastern Uganda, in the range of 8.0 per mill to 13.7 per mill, and are in extremely narrow range compared with those of the other carbonatite body in Kavirondo Rift, i.e., according to Deins and Gold (1973), 10.1 per mill to 28.2 per mill in Rangwa, 9.4 per mill to 26.5 per mill in North Ruri, 11.8 per mill to 25.3 per mill in South Ruri and 9.7 per mill to 22.5 per mill in Homa Mountain. It is estimated that the carbonatite body in Kavirondo Rift should be subject to an erosion to a shallow depth and is of

Table II–1–11 Oxygen Isotope Data of the Buru Hill Carbonatite Complex

| Sample Number | Location (Depth:m) | Sample Description | Type | $\delta^{18}O$ (SMOW) (0/00) |
|---|---|---|---|---|
| BRL–1–G* | 180.00 | Greenish grey altered nephelinite subjected to strong carbonitization | WR | +11.5 |
| BRL–1–H* | 198.10 | Dark grey medium-grained magnetite rich ferro-carbonatite | WR | +10.1 |
| BRL–1–J* | 76.00 | Black small calcite crystals in a drose of weathered carbonatite | Cal | +25.9 |
| BRL–2–F | 83.50 | Pale grey to white banded fine-grained carbonatite | WR | +13.7 |
| BRL–3–G | 57.40 | Pale grey to white banded fine-grained carbonatite rich in magnetite | WR | +10.8 |
| BRL–3–J | 84.50 | Pale grey carbonatite breccia rich in chlorite | WR | +10.3 |
| BR–04–A* | 10.40 | Dark grey compact very fine-grained siliceous iron ore | WR | +11.0 |
| BR–13–B* | 32.80 | Dark grey ferrocarbonatite subjected to oxidation by weathering | WR | +5.8 |
| BR–16–A* | 30.00 | Pale grey biotite bearing granitic gneiss | WR | +8.6 |
| BR–23–B | 20.50 | Pale grey granitic gneiss rich in porphyroclast of K-feldsper | WR | +7.6 |

* Samples taken from Phase II boring, Others are from Phase III boring.
WR: whole rock, Cal: calcite

volcanic to subvolcanic composition of surficial character, meanwhile, the carbonatite body in Uganda should be of subvolcanic composition. According to Deins and Gold (1973), the disparity of the value of the range of oxygen isotope ratio is estimated to be caused by a subjection of surficial alteration process for the carbonatite body in Kavirondo Rift. Therefore, the current depth of the erosion of the Buru Hill carbonatite, which shows an approximate value of the range of oxygen isotope ratio to that in eastern Uganda, should possibly correspond to being subvolcanic.

Siliceous iron ore shows a mostly equal value of oxygen isotope ratio to that of carbonatite. Based on that the siliceous iron ore shows a character of mineral composition and ore texture formed under the low-temperature hydrothermal condition, siliceous iron ore has been estimated in the second-year Report to be possibly formed by a reaction of the residual solution, rich in silica in relation with the carbonatite consolidation, and meteoric water. However, the result by the current work, which conducts a divergence of views against the last estimation the above, shows that the siliceous iron ore is of primary magmatic origin, identical to the carbonatite.

Weathered carbonatite has the $\delta^{18}O$ value of 5.8 per mill to clearly show a reaction evidence by surface water.

Calcite collected from a cavity of weathered carbonatite has the $\delta^{18}O$ value of 25.9 per mill, which is extremely higher than that of carbonatite. It is presumed that the calcite was formed by low-temperature hydrothermal solution or Ca-rich solution after a reaction under the atmospheric condition rich in $^{18}O$.

The similar $\delta^{18}O$ values of two specimen of gneiss, adjacently located to carbonatite body, are obtained by the current work. They fall into the average field of granite of the range of oxygen isotope ratio. It is likely presumed that an exchange of oxygen isotope were little during the process of metamorphism and carbonatite intrusion.

## 1-6 Discussion

### 1-6-1 Characters of mineralization

The Buru Hill carbonatite is the sole body in Homa Bay area, in which a supergene enrichment was enhanced by a development of weathered-oxydized zones and REE were up-graded to the ore-level. The Buru Hill carbonatite, intruded on the stage of the early Neogene Tertiary age - 22 Ma -, has been subjected to weathering and erosion until Recent under the tropical climate conditions. It is estimated that the body currently shows a form of cylindrical mass on ground surface, which is considered to be pertaining to subvolcanic facies, after having been subjected to weathering, by which the most portions of volcanic facies in upper part of the carbonatite body, i.e., eruptive facies, ring dykes and cone-sheets, have been eroded off. The current massive carbonatite body in Buru Hill is surrounded by granitoid gneiss, basement rock in the area, which has been rippedly up-lifted upward by carbonatite intrusion and has been resistive to weathering. Consequently, the surficial portion of carbonatite body has been under the structural shelter by granitoid gneiss to sustain little removal of earthy and/or lateritized materials derived from the carbonatite by erosion toward outsided periphery. The above is estimated to be a major geological mechanism related to the development of weathered soils and lateric materials in Buru Hill area.

### 1-6-2 Possibility of industrial and economical development of Buru Hill Carbonatite

An ore body of REE minerals is formed in the oxidized zone in upper portion of carbonatite body in Buru Hill area.

Examinations of various factors, shown below, in connection with ore reserves and ore grade are required for an establishment of reliable estimation related to the industrial and economical development of the ore boy in Buru Hill area in future. Those include: 1. Recoverable metallurgical extraction technology of economical elements, 2. Estimations of capital and operation costs, based on the programmes of mine development, plant constructions and mining/mineral processing, 3. Marketability of end products and 4. Environmental and infrastructural impacts in social measures and related terms.

Examinations of those factors, the above, are excluded in the current work programme. A trial comparative geological and industrial examination of the Buru Hill carbonatite ore body, from a stand point of ore reserves and ore grade, with that in the world, which produces REE minerals as the main or by-product of the mine, is stated by the current work as follows (Fig. II -1-14):

Carbonatite ore deposit in Brazil is considered to be one the appropriate examples for the purpose of the current comparative study, meanwhile, large and high-grade-ore mines, the Mountain Pass mine, U.S.A. and the Baiyan Obo mine, China are excluded.

The Araxa ore deposit, Brazil and the Catalao ore deposit, Brazil are to be ranked on an equivalent level of ore reserves to that in Buru Hill, however, those are operated with satisfactory performances under the conditions of production ore grade of more than ten (10) percent of Total REO, associated with niobium, phosphorus, titanium, barium and etc. as the major or by-products. The Pocos de Cardos ore deposit, Brazil, is of small scale of ore reserves, however carries higher ore grade than that of Buru Hill. The Pocos de Cardos mine, associated with by-products of phosphorus and high-graded titanium ore, is operated to satisfy the national demands in the country, by what the development of REE ore body is made possibly feasible.

The Buru Hill ore deposit is estimated to be under the disadvantageous conditions, those are:

1. Inevitably low contents of REE minerals, and
2. Unlikelihood of an establishment of successful recovery of by-products, such as phosphorus, niobium and etc..

Inversely, the Buru Hill ore body is situated in favourable location and geometric condition, such as with an easy applicability of open pit mining operation and etc.. A comprehensive evaluation and feasibility study for an economical development of the ore body will be required by some possibility in more details in a future.

# CHAPTER 2 KUGE-LWALA AREA

## 2-1 Methods of Survey

Diamond drill operations, to investigate the group of ferrocarbonatite dyke, located in the eastern end of the Kuge Hill carbonatite body, were implemented by the current investigation programme.

Six (6) diamond drill holes, 60 metres deep each, 360 metres in total, were operated.

Diamond drills holes were allocated ca. linearly north-south directionally, having 100 metre-intervals. Hole azimuths were established to achieve perpendicular intersections to the dyke and also hole angles were set up to be 50 degrees declined against westerly dipping dyke.

Detailed examinations of drill cores by unaided eye were carefully made to summarize the drill core logs on a scale of 1:200. Required number of samples of minerals and rocks were collected to be sent to laboratory tests. Mineralized portions of the drill cores were chemically analysed at an every intersected portion of ores. The 81 samples were chemically analyzed. The geological cross sections with drill hole logs projections, on a scale of 1:1,000, were delineated after geological compilations of surface mappings and drill logs. The results of the chemical analyses of ores were applied to the estimations of inferred ore reserves and grades.

## 2-2 General Geology

### 2-2-1 Kuge-Lwala area

An occurrence of ijolite and carbonatite is known in Wasaki Peninsula, to the west of the town of Homa Bay. Kuge-Lwala area is located in south-western end of the above occurrence. Carbonatite complexes of small scale are known in Kuge Hill and in Lwala. The body at Kuge Hill is of an alvikitic cone-sheet, associated with a ferrocarbonatite dyke at the eastern end. The body at Lwala majorly consists of ferruginous breccia, carbonatite breccia and alvikite, associated with breccias of carbonatite.

The carbonatite cone-sheet in Kuge Hill represents the summit of the intrusive body, beneath of which in deep underground, an occurrence of massive body is inferred. Ferrocarbonatite dyke shows 30 to 40 metres wide, extending ca. 600 metres south-northerly, and is steeply dipping toward west.

The group of carbonititic body in Lwala occupies an area of 0.3 square kilometre in close extent. Geological map and geological profile of the area, by the first-year programme 1987, are shown in Fig. II -2-1.

Generalized geological column of Kuge-Lwala Area is shown in Figure II -2-2, and Geological map of Kuge Hill is in Figure II -2-3.

### 2-2-2 Kuge Hill

General geology in Kuge Hill, as shown in Fig. II -2-3, is comprised of Nyanzian metabasalt of the basement rock, which is intruded by alvikite, ferrocarbonatitie and etc.. Major geological mode of the carbonatite intrusion in the area shows a semi-circular structure, opened toward south-westerly.

(1) Nyanzian metabasalt

Nyanzian metabasalt is widely distributed from central to western half portion of Kuge Hill. The rock occurs in the form of a roof against the carbonatite cone-sheet of Kuge Hill, subjected to intense fracturing and shattering.

The rocks of the unit are dark grey to dark greenish grey, aphanitic, fine-grained and compact. Strainings by iron oxide minerals and filmy fine veins of carbonate minerals along cracks are frequently observed.

(2) Alvikite

Alvikite is distributed in central part of the area, surrounding metabasalt roof mentioned above.

The unit strikes N-S and dips steeply westwards in western part of the area, strikes E-W and dips steeply northwards in the north and strikes N-S to NE-SW and dips moderately west to northwestwards in the east, showing a circular structure. The southwest part of the area, inversely, shows irregular strikes and dips.

The rocks of the unit show various colours, such as pale grey, grey, greyish brown and brown, and are fine to medium-grained, comprising mainly carbonate minerals with subordinate mica, magnetitic and apatite. A rock facies, which is rich in magnetite, sometimes resembles to ferrocarbonatite.

(3) Alvikititic breccia

The unit is distributed on the crest of Kuge Hill as a small lenticular body. The body contacts to the northern margin of the alvikite body, which forms the main carbonatite facies in the area, suggesting that the unit is of brecciated facies of the alvikite body.

The unit is abundantly comprised of carbonatite breccias, several centimetres to several ten (10) centimetres long, and subangular metabasalt breccias. Matrix is composed of carbonatite fragments, greyish brown to raddish grey, carrying abundant small cavities.

(4) Ferrocarbonatite

Ferrocarbonatite is distributed in the eastern end of Kuge Hill, in an extended form south-northerly. The intrusive structure of the unit shows that strikes north by northwesterly-south by south easterly to north-southerly, and dips 60 to 80 degrees toward west to vertical. The unit is 60

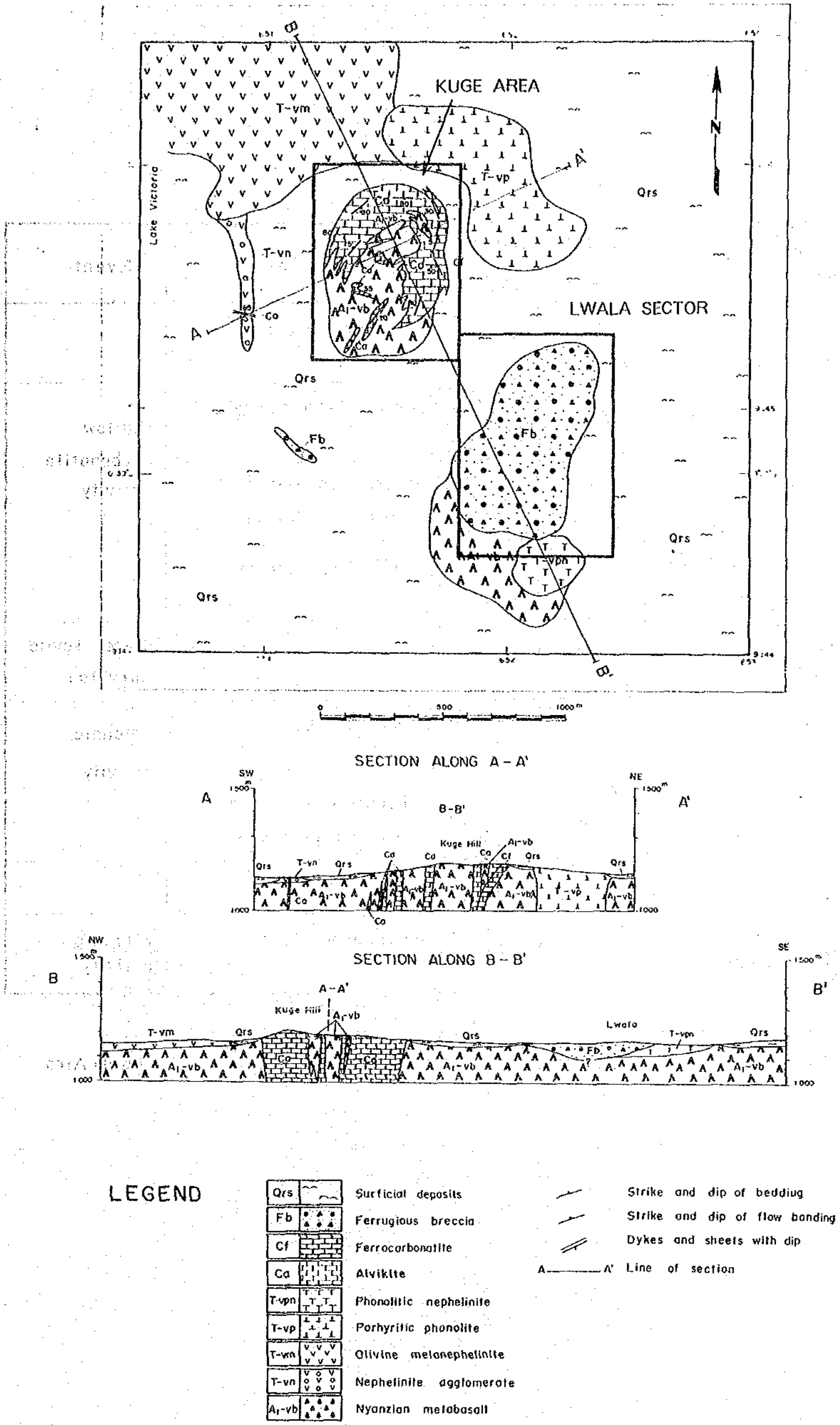


Fig. II–2–1 Geological Map of the Kuge – Lwala Area

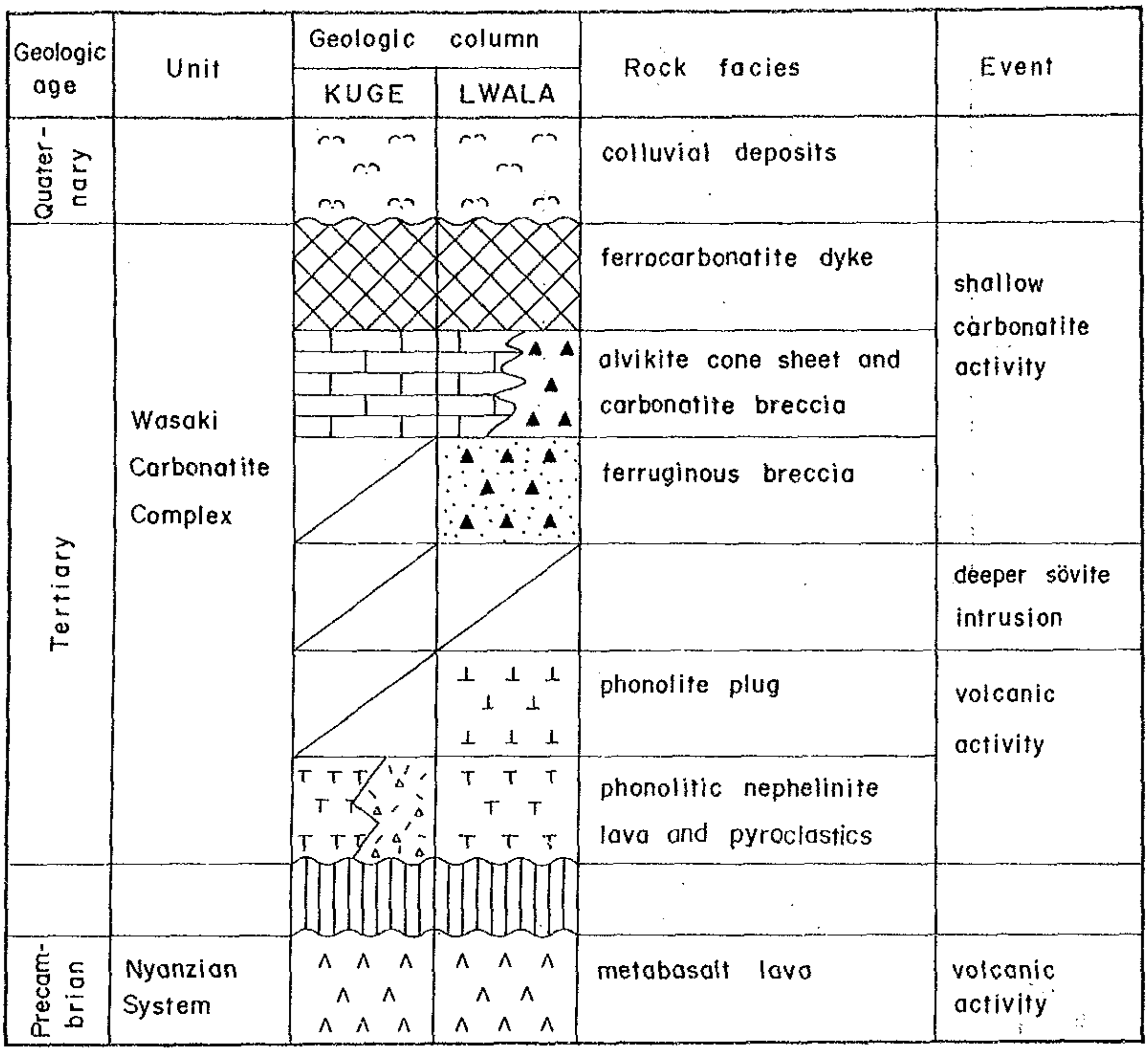



Fig. II–2–2 Generalized Geological Columnar Sections of the Kuge – Lwala Area

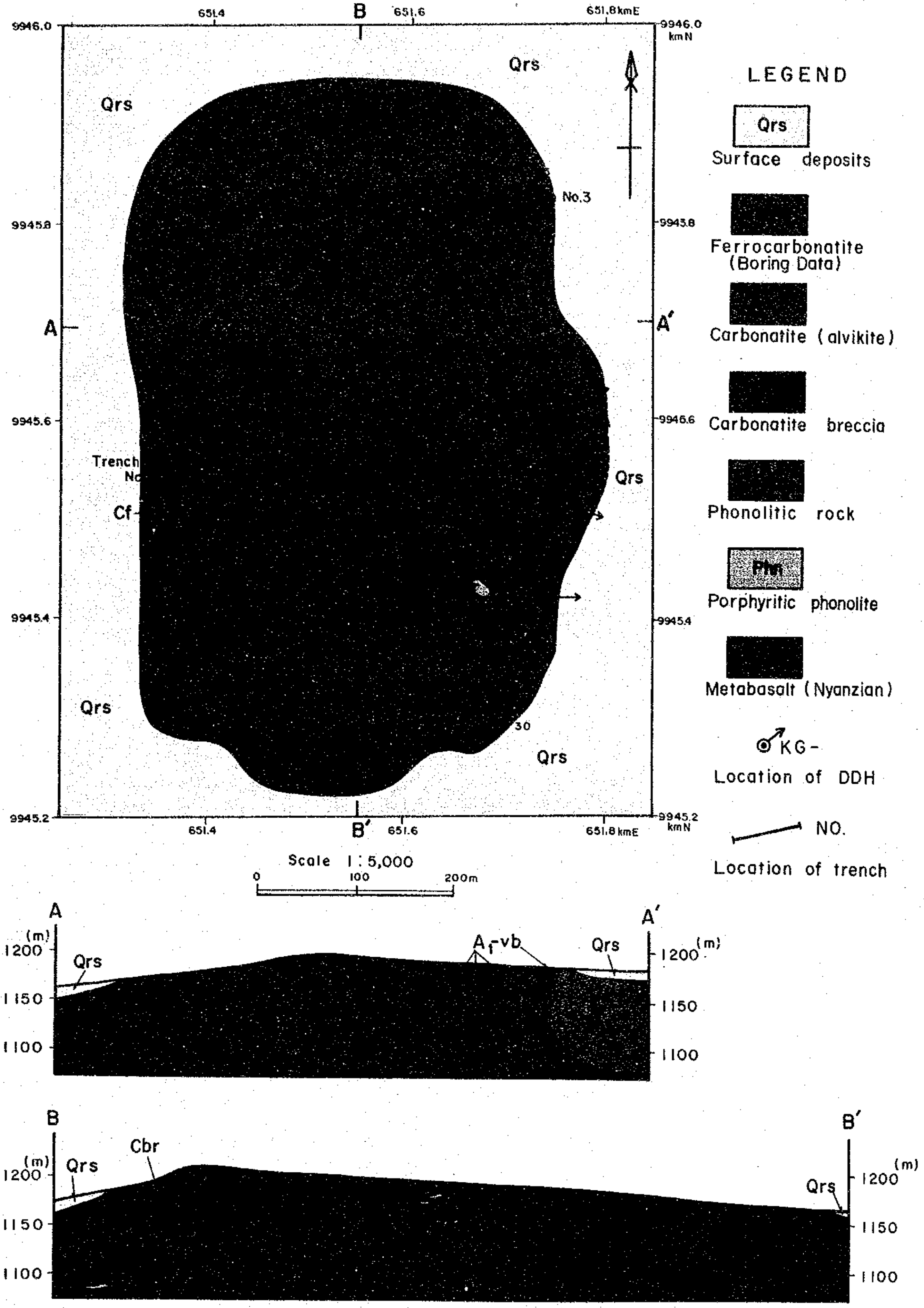



Fig. II–2–3 Geological Map of the Kuge Hill in the Kuge – Lwala Area

metres wide in maximum, and is extending 600 metres. Additional two brecciated intrusive bodies of small scale, in a form of complexes of several number of dykes, are distributed in south-western portion of the area. Ferrocarbonatite, which is observed in a form of intrusive body at the contact of alvikite and metabasalt, is considered to be of the latest product of the Kuge Carbonatite activity.

Ferrocarbonatite is subjected to an intense weathering and iron oxide strainings, and shows dark brownish grey, dark brown, reddish brown and etc., rich in iron content and is composed of carbonate minerals. The units frequently carry abundant fine breccias of metabasalt, by what it shows a similar appearance of breccia rock. It is also dark brown, frequently of fine grained facies, associated with bandings of yellow minerals. Under the microscope, ferrocarbonatite is majorly composed of carbonate minerals, barite, iron minerals, associated with bastnaésite and mica mineral. Carbonate minerals include calcite, ferruginous calcite, iron-manganese bearing calcite. Iron minerals are entirely weathered to forming goethite.

## 2-3 Results of Diamond Drill Exploration

### 2-3-1 Outline

Diamond drill operations of six (6) declined holes, the total metrage of three hundreds and sixty (360) metres (60m × 6 holes), were implemented in the Kuge-Lwala Area during the course of the current survey. Figures II-2-4 and II-2-5 show the area, where diamond drill exploration works were implemented, Table II-2-1 shows drill hole locations, site elevations, hole bearings, hole declination degrees and hole depths.

Table II-2-1 Location of Diamond Drill Hole

| DDH No. | UTM Coordination X (mE) | Y (mN) | Elevation, metre | Hole bearing from GN, degree | Hole declination, degree | Hole depth, drilled, metre |
|---|---|---|---|---|---|---|
| KG-1 | 651,650 | 9,945,895 | 1,185 | 40° | -50° | 60.10 |
| KG-2 | 651,695 | 9,945,805 | 1,185 | 70° | -50° | 60.10 |
| KG-3 | 651,702 | 9,945,710 | 1,183 | 70° | -50° | 60.10 |
| KG-4 | 651,764 | 9,945,620 | 1,183 | 70° | -50° | 60.10 |
| KG-5 | 651,759 | 9,945,518 | 1,190 | 110° | -50° | 60.10 |
| KG-6 | 651,735 | 9,945,420 | 1,184 | 90° | -50° | 60.10 |

### 2-3-2 Diamond drill operations

(1) Mobilization, Demobilization

Equipment and materials of drill operation supplemented for the use of Kuge-Lwala Project were transported by seacargo from Japan to Mombasa, by inland cargo from Mombasa to Buru Hill, to be delivered on 30th August 1989. All of the drill rigs, equipments and materials,

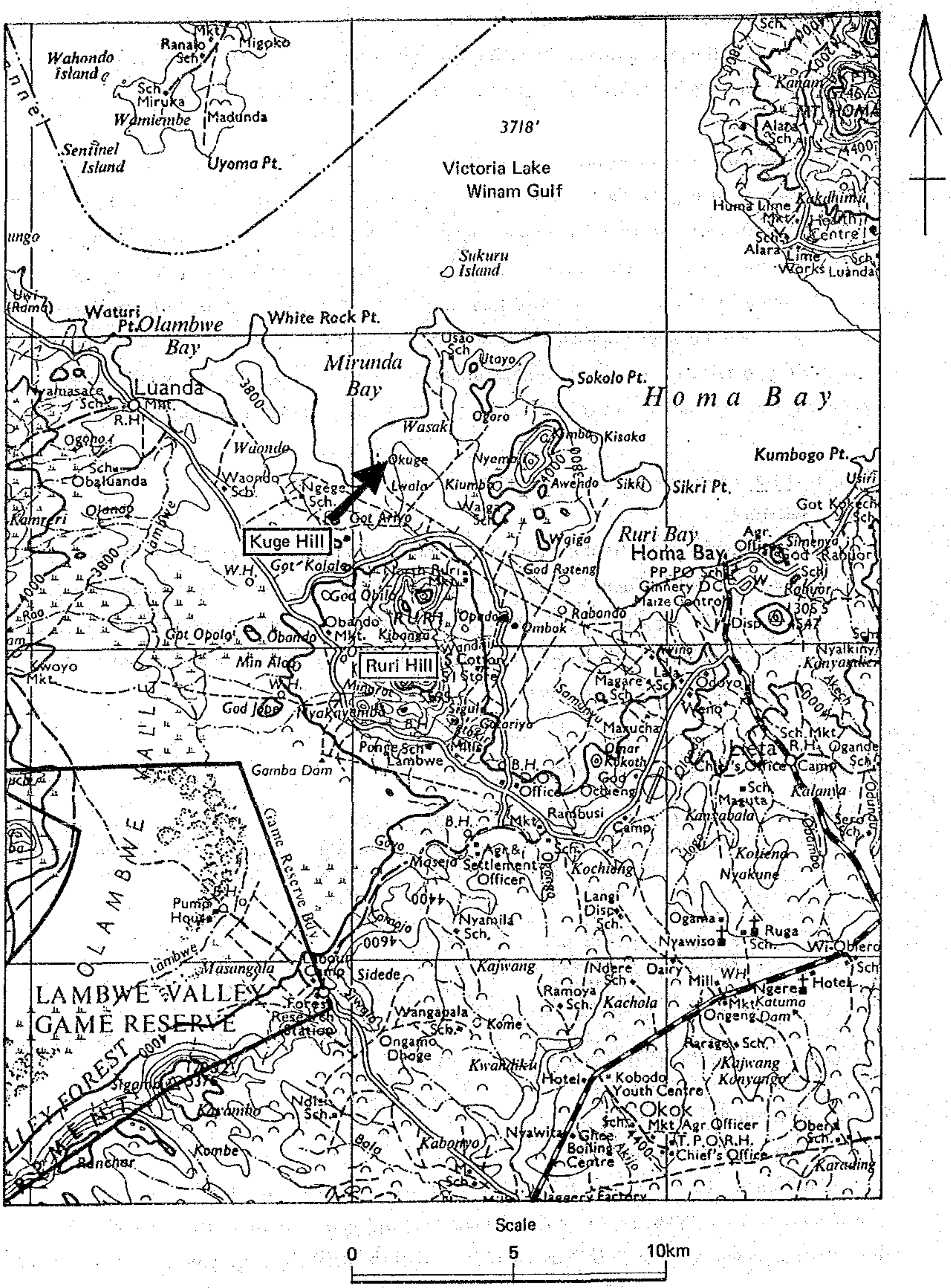



Fig. II–2–4 Location Map of Drilling Area, Kuge – Lwala Area

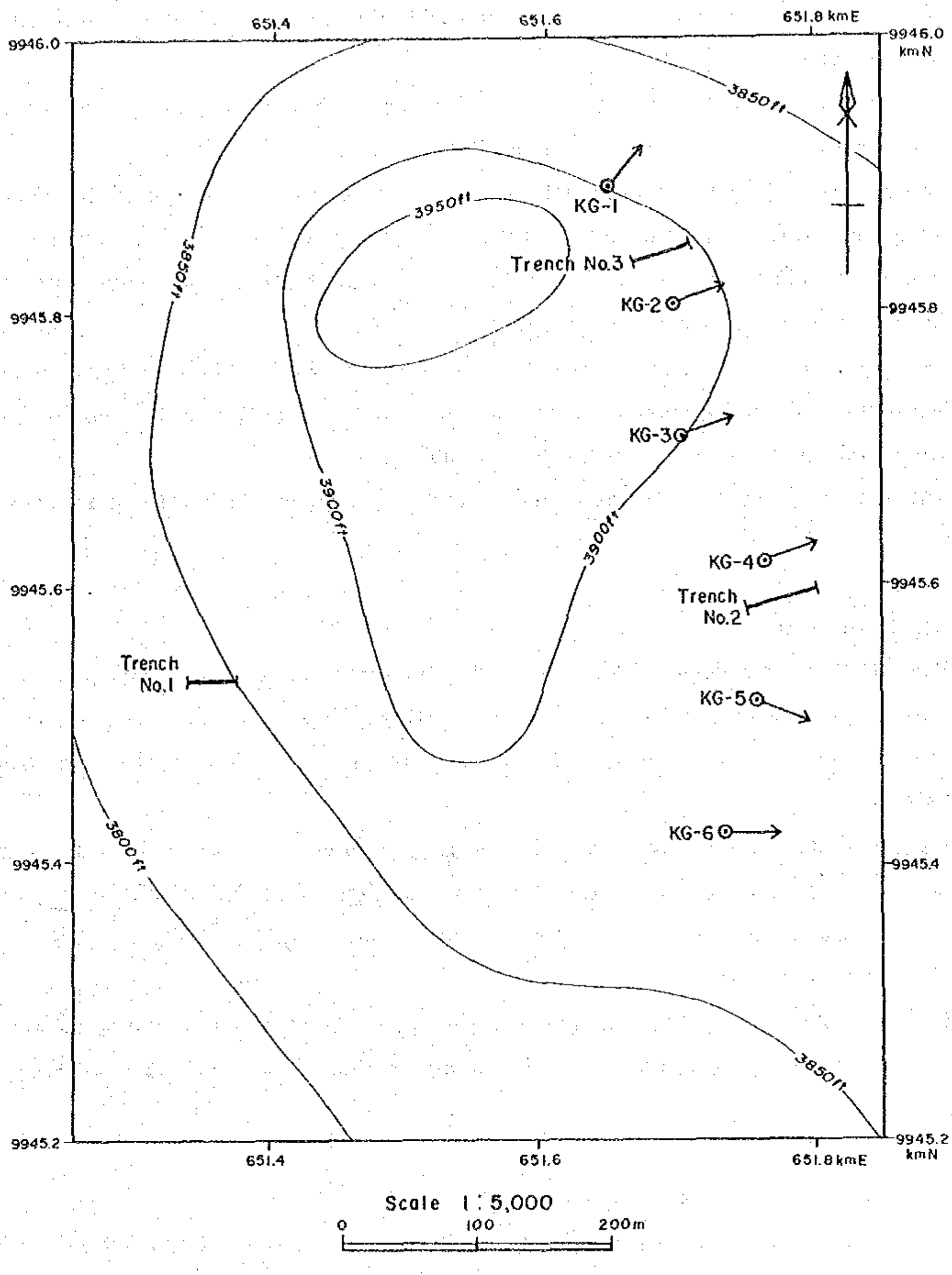



Fig. II–2–5 Location Map of the Drilling Sites in the Kuge Hill including those which were used for Buru Hill Project were then transported to Kuge-Lwala on 31st August 1989.

The drill operation team crews have initially removed to Homa Bay Camp simultaneously with drill equipments and have then further removed to the homestead camp near drill sites on 5th September 1989.

Provisional works were completed on 3rd September 1989, followed by a commencement of the first hole operation, KG-4, on 4th September 1989.

The drill operation crews have achieved a satisfactory performance of the works to establish an uneventful completion of the total work, six (6) holes, totalling 360 metres, on 20th September 1989, followed by a demobilization progress of the total rigs and equipments, to be stored in a warehouse of the Kisumu Office, MGD.

The Japanese Survey Team left Kisumu on 28th September 1989 to have Report Meetings to the Government Organizations in Nairobi, concerned to the Project, and then left Nairobi on 8th October 1989, arrived in Tokyo on 9th October 1989.

The general progress of the works and itinerary of Japanese Survey Team are shown in Apx. 36.

(2) Local situations

Kuge Hill forms a dome-like hill, occupying an approximate area of 500 metres east-westerly by 700 metres north-southerly. The crest of Kuga Hill is elevated some 80 metres high above circumscribing flat agricultural field and some 90 metres high above the water level of Lake Victoria.

Kuge Hill is accessible from Homa Bay through unsealed local road C-19 and branching path - lorry accessible under satisfactory weather condition -. Drill sites of the project are allocated on an eastern gentle slope foot of Kuge Hill, to where jeeps are easily accessible after a light road construction work.

Water supply to the drill sites was made by pumping water from an inlet of Lake Victoria, 1,200 metres westerly apart, due to an insufficient availability of water flow near the Kuge Hill environs.

(3) Rigs to be used and drill techniques

The drill rigs, which were used in the Buru Hill Project, and an additional one derrick for a declination drill operation, were used for the Kuge-Lwala Project. A conventional automatic suction pump was deployed on Lake Victoria coast, relayed by a plunger-type pump in a middle-way station to the drill sites. A maximum pumping head was 70 metres, a maximum pumping distance was 1,500 metres.

Essentially, the wire-line drill technique was employed for drill work. Dry drill technique and core-pack-tube technique were employed for the operations of soft brittle rocks. Cores of NQ and/or BQ size were recovered.

Apx. 39 and Apx. 40 show quantities of drill rigs and equipments, general consumables and diamond drill bits.

(4) Operation organization and personnel

The similar operation organization to that of the Buru Hill Project was embodied as follows:

| | Number of Japanese Drill Engineer | Number of Kenya Counterpart | | Number of Labour |
|---|---|---|---|---|
| 1st Drill Party | 1 | 2 | | 2 |
| 2nd Drill Party | 1 | 2 | | 2 |
| Transportation Party | 1 | – | | 5 |
| Access road construction & site preparation | (Transportation Party concurr.) | – | | 5 |
| Pump maintenance | – | Daytime<br>Night-time | 2<br>2 | 8 |
| Guard at site | – | Daytime<br>Night-time per site | 1<br>2 to 3 | 9 |
| Guard at materials storage | – | Daytime<br>Night-time | 1<br>2 | 3 |

(5) Drill operations

Drill operations, which were organized by the similar embodiment to that of the Buru Hill Project, were implemented by 2 shifts per 16 hours per day by embodying 2 drill parties. One transportation - mounting/dismounting party was embodied by one shift per daytime 8 hours per day.

Two drill rigs were employed during the current drill operations. While one rig was in drill operations, another rig was removed to transportation-mounting. It was effective to avoid any breaking out of work suspension and to establish a continuous drill performance.

The major performances of diamond drill operations, general progresses of the whole operation and the individual progress of each hole of the current survey are shown in Apxs. 37 and 38.

### 2-3-3 Geological notes by drill hole

General geology, observed in drill holes in Kuge Hill area, is shown below:

(1) KG-1 (60.10 metres deep), Apx. 30

| | | |
|---|---|---|
| 0 - 5.80 m | : | Calcrete. Carbonatite and metabasalt are observed as breccias. |
| 5.80 - 13.50 m | : | Metabasalt, fractured and brecciated. Breccia-interstices are cemented by carbonate minerals. Two alvikite dykes, rich in magnetite, are observed at the section 7.30 metres to 9.30 metres depths. |
| 13.50 - 15.70 m | : | Alvikite in upper half, and weathered brown ferrocarbonatite in lower half. |
| 15.70 - 19.70 m | : | Fine-grained carbonatite, rich in magnetite. Disseminated by green secondary minerals. |
| 19.70 - 32.10 m | : | Phonolite to phonolitic nephelinite, intensely weathered and purplish grey. Dykelets of carbonatite or ferrocarbonatite, less than one metre thick, are observed. |
| 32.10 - 37.60 m | : | Weathered carbonatite. Includes xenolithic fragments of phonolitic volcanic rock. |
| 37.60 - 49.75 m | : | Phonolitic volcanic rock, medium-grained and porphyritic. Frequently intruded by ferrocarbonatite fine veins and fractured. |
| 49.75 - 60.10 m | : | Ground water table is situated at 49.75 metres depth, below which phonolitic volcanic rock is unweathered.<br>Carbonate-mineralization, carbonate mineral fine veins are well-developed in a whole. |

(2) KG-2 (60.10 metres deep), Apx. 31

| | | |
|---|---|---|
| 0 - 1.20 m | : | Calcrete. Carbonatite and metabasalt are observed as breccias. |
| 1.20 - 15.10 m | : | Medium-grained carbonatite, brown-stained by weathering and with intermediate petrological character of ferrocarbonatite and alvikite. Associated with an abundant quantity of sub-rounded breccias of bleached metabasalt, resultant in showing an appearance of conglomeratic facies. |
| 15.10 - 36.80 m | : | Weathered brown carbonatite, locally earthy. Frequently associated with xenoliths of massive metabasalt, less than 50 centimetres diameter, sparsely with fine breccias of metabasalt. |
| 36.80 - 47.50 m | : | Phonolite lava, fine-grained, porphyritic and grey. Frequently intruded by fine veins of carbonatite or ferrocarbonatite. |

| | | |
|---|---|---|
| 47.50 - 57.80 m | : | Phonolitic to nephelinitic pyroclastics, weathered to purplish grey. Mostly composed of lapilli tuff and tuff. Two fractured zones in lower part. |
| 57.80 - 60.10 m | : | Porphyritic phonolite, grey to purplish grey. Carbonate-mineral fine veins are well-developed. |

(3) KG-3 (60.10 m metres deep), Apx. 32

| | | |
|---|---|---|
| 0 - 2.10 m | : | Calcrete. |
| 2.10 - 11.20 m | : | Fine-grained carbonatite, pale grey. With porous texture by a possible detachment of metabasalt fine breccias. |
| 11.20 - 26.70 m | : | Massive ferrocarbonatite, brown. Sparsely disseminated by green secondary minerals. Intensely fractured metabasalt xenoliths cemented by carbonate-minerals fine veins, are included block-wisely. |
| 26.70 - 34.90 m | : | Heterogeneous carbonatite, pale grey. Includes metabasalt xenoliths, block-wisely and is intruded by ferrocarbonatite fine veins. |
| 34.90 - 38.20 m | : | Massive ferrocarbonatite, brown. Rich in green secondary minerals. |
| 38.20 - 43.15 m | : | Fine-grained carbonatite, intensely weathered. Associated with xenoliths of green metabasalt. |
| 43.15 - 49.30 m | : | Porphyritic phonolite, pale brown to purplish grey. Carbonate-mineral veins are well-developed. |
| 49.30 - 60.10 m | : | Intensely weathered brown carbonatite or ferrocarbonatite of intermediate composition. Associated with massive xenoliths of fractured phonolite. |

(4) KG-4 (60.10 m metres deep), Apx. 33

| | | |
|---|---|---|
| 0 - 1.70 m | : | Calcrete. Carbonatite and ferrocarbonatite are observed as breccias. |
| 1.70 - 20.70 m | : | Massive ferrocarbonatite, brown. Associated with an abundant quantity of fine breccias of metabasalt, resultant in showing an appearance of conglomeratic facies. |
| 20.70 - 23.70 m | : | Brown carbonatite, intensely weathered and porous. |
| 23.70 - 25.75 m | : | Porphyritic phonolite, intensely weathered and grey. Carbonate-mineral fine veins are well-developed. |
| 25.75 - 39.90 m | : | Coarse-frained tuff to tuff breccia, calcareous and pale grey to pale brown. Breccias are mostly composed of phonolite and matrix is calcareous. Fractured zones are frequently observed in lower part. |
| 39.90 - 43.60 m | : | Massive ferrocarbonatite, brown. Speckled by black materials-possibly manganiferrous. |

43.60 - 47.00 m : Fine-grained phonolite, weathered and grey. Intensely argillized and carbonate-mineralized.

47.00 - 58.50 m : Carbonatite, intensely weathered and grey. Magnetite is weathered to hematite or goethite.

58.50 - 60.10 m : Porphyritic phonolite, intensely weathered and grey.

(5) KG-5 (60.10 metres deep), Apx. 34

0 - 1.40 m : Surficial sands and pebbles. Composed of carbonatite breccias and sand matrix.

1.40 - 11.50 m : Fine-grained ferrocarbonatite, brown. Associated with an abundant quantity of sub-rounded small breccias of metabasalt.

11.50 - 21.60 m : Fine-grained ferrocarbonatite, brown. Associated with an abundant quantity of fine breccias of talcose white metabasalt. Includes xenoliths of massive metabasalt, less than two metres diameter.

21.60 - 32.50 m : Massive ferrocarbonatite, brown. Associated with a small quantity of breccias of talcose white metabasalt.

32.50 - 38.90 m : Massive carbonatite, fine grained, pale brown to ferrocarbonatite of intermediate composition. Sparsely disseminated by viridescent fine-grained secondary minerals.

38.90 - 51.05 m : Ferrocarbonatite, brown to pale brown. Locally earthy by an intense weathering.

51.05 - 53.20m : Phonolite, porphyritic, fine-grained and grey.

53.20 - 60.10 m : Intensely weathered, pale brown carbonatite to ferrocarbonatite of intermediate composition. Includes bleached metabasalt, 1.5 metres wide.

(6) KG-6 (60.10 metres deep), Apx. 35

0 - 1.00 m : Calcrete.

1.00 - 7.60 m : Fine-grained carbonatite, pale brown. Biotite and magnetite are included.

7.60 - 11.60 m : Fine-grained, pale brown carbonatite to ferrocarbonatite of intermediate composition. Mica minerals, biotite or phlogopite, are included.

11.60 - 15.50 m : Ferrocarbonatite, brown and massive, partly banded. Includes metabasalt breccias.

15.50 - 19.05 m : Porphyritic phonolite, fractured. Includes metabasalt breccias.

| | | |
|---|---|---|
| 19.05 - 32.00 m | : | Metabasalt, greenish grey. Intensely fractured, cracks and filled up by carbonate minerals. Pale-brown-stained in a whole. |
| 32.00 - 42.85 m | : | Intensely fractured metabasalt, greenish grey. Carbonate-mineral veins are well-developed. Ground water table is situated at some 32.00 metres depth. Forms an unweathered zone in a whole, entirely dissociated from limonite stainings. |
| 42.85 - 43.75 m | : | Fractured zone. Ferrocarbonatite fine veins are well-developed. |
| 43.75 - 60.10 m | : | Alternations of phonolitic pyroclastic rocks and phonolite lavas, bedded by less than 4 metre-thick sequence alternates. |

### 2-3-4 Mineralization

The host rock of REE concentration-mineralization-in Kuge Hill area is confined to the dykes of ferrocarbonatite, distributed in eastern foot of Kuge Hill. The dykes are composed of ferrocarbonatite and also of carbonatite, which shows an intermediate facies of ferrocarbonatite and alvikite, and include metabasalt of basement rock and phonolitic rock, which had preceded carbonatite intrusions. The dyke shows an occurrence of intrusive bodies at the contact of Kuga Hill Carbonatite Complex and outer phonolitic volcanic rock. They are estimated to be of the latest product related to the carbonatite activities.

Carbonatite, which carries an intermediate facies of ferrocarbonatite and alvikite, characteristically shows banded textures and is somewhat less pale coloured than ferrocarbonatite. However, chemical disparities of carbonatite, the above, and ferrocarbonatite are not remarkably observed in connection with the results of geochemistry of whole rock analysis and REE contents. Apparent disparities of both rocks are presumed to be caused by the differences of the orders of intrusive activities and the degree of oxydation by weathering.

The results of analytical geochemistry of the dykes, as shown in the following section, 2-4, are approximate to those of the primary mineralized zone in Buru Hill. The dykes are distributed along the hill foot of gentle eastern slope, from where the weathered earthy materials should be topographically prone to be removed outward from the in-situ sites of carbonititic dykes. It is, consequently, presumed that the in-situ sites of dykes have not been provided under the topographical condition, where weathered soils and lateritic materials should have been residually accumulated. It is also presumed that the dykes have not been subjected to supergene enrichment, resultant in having an REE concentration, which is approximate to that of the primary concentration of REE. The contents of REE in ferrocarbonatite rocks in the area, which is not to be ranked to the ore grade level, is presumed to be caused by a lack of the supergene enrichment in the area.