2-4 Discussion

From the results of geological, geochemical and drilling surveys performed in Tundulu sector through the first and second phases, the following facts have been clarified.

Carbonatites are developed showing superposed double ring structure centering Nathace Hill. The outer ring constitutes Tundulu Hill. Generally speaking, among the carbonatites showing the double ring structure, those of early intrusion constitutes the outer ring and are composed of sovitic one.

As carbonatites on Tundulu Hill are developed in the outer side than those on Nathace Hill and are composed of sovitic one, it is inferred that the former intrude comparatively in the earlier stage of the igneous activity.

Carbonatites on the Nathace Hill are sovitic, ankeritic and sideritic ones and apatite rock. Most of them are developed on the eastern slope on the Hill, showing a half ring structure. The following two litho-stratigraphic units have been discriminated for the carbonatites; namely, the upper unit is mainly sideritic and the lower one is apatite rock, sovitic and ankeritic carbonatites.

Carbonatites changes the distribution pattern of strike to surround Nathace Hill and tend to dip 70° to 90° towards the top of the hill (Fig. 13).

REE- and phosphorus- mineralized zones are recognized in both units on Nathace Hill described above at JMT-7, 14 and 19.

Concentrated apatite rock is found in the lower unit as rather irregularly-shaped body, the dimension of which is 150m in length and 20 to 30m in width.

Carbon and oxygen isotopic ratios are analyzed for carbonatite and apatite rock from Nathace Hill in order to elucidate the petrogenesis of these rocks.

Analyzed results for apatite rocks (8Y153 and 8Y154), composed of apatite, quartz and calcite and for sideritic carbonatite (JMT-22), composed of ankerite and siderite, are $\delta^{13}C=-7.4‰$ to $-5.4‰$ and $\delta^{18}O=+5.4‰$ to $+8.7‰$, which suggest that these rocks are igneous in origin. The results for carbonatites (JMT-7 and -26), composed of kutnahorite and calcite, are $\delta^{13}C=-5.0‰$ to $-2.3‰$ and $\delta^{18}O=+20.7‰$ to

+22.0‰. Thus the rocks are inferred to have undergone alteration through contaminated by meteoric water (See 4-2).

Based upon the results of drilling as well as upon of the second phase survey, a preliminary estimation of ore reserve has been made for the mineralized zones.

The estimation of ore reserves for REE-mineralized zone is made following the same method as in the case of Songwe sector. The estimation discriminates three ore bodies on the Nathace Hill. In table 10, are shown ore reserves and contents of REO, Sm, Eu and Tb for each body (Fig. 14).

As in the case of Songwe sector, it is impossible to compare the ore reserves of 0.6 million tons with those of other mines.

REO content is nearly the same as that of Bayan Obo Mine.

Tab.10 Calculation of ore reserves (REO), Tundulu

Block No.	JMT	(m^2) Area	(m) Average Hight	Ore (t) Reserves	Grade (ppm)			
					REO	Sm	Eu	Tb
R1	14, 22, 26, 27	5,480	26.4	434,020	22,414	272.5	53.8	16.9
R2	25	1,760	25.4	134,110	11,912	256.4	88.4	29.9
R3	17	1,880	10.3	58,090	30,187	336.5	49.0	5.2
Total				626,220	20,886	275.0	60.8	18.6
Bayan Obo (China)				——	20,000	567	67	17

A preliminary estimation of ore reserve has been made for the phosphorus-mineralized zones assuming the following:

cutoff grade; P more than 2.2% (5% in P_2O_5 equivalent)

thickness; arithmetic mean of zones which are assumed to extend more than 10m

area; area of apatite rock and apatite-bearing carbonatite cropped out on the surface

density of ore; 3.0 (REO; 3.0, apatite; 3.1)

The estimation discriminates a body in the present sector. The area with high potential for phosphorus deposit is generally identical with that for REE deposits shown above.

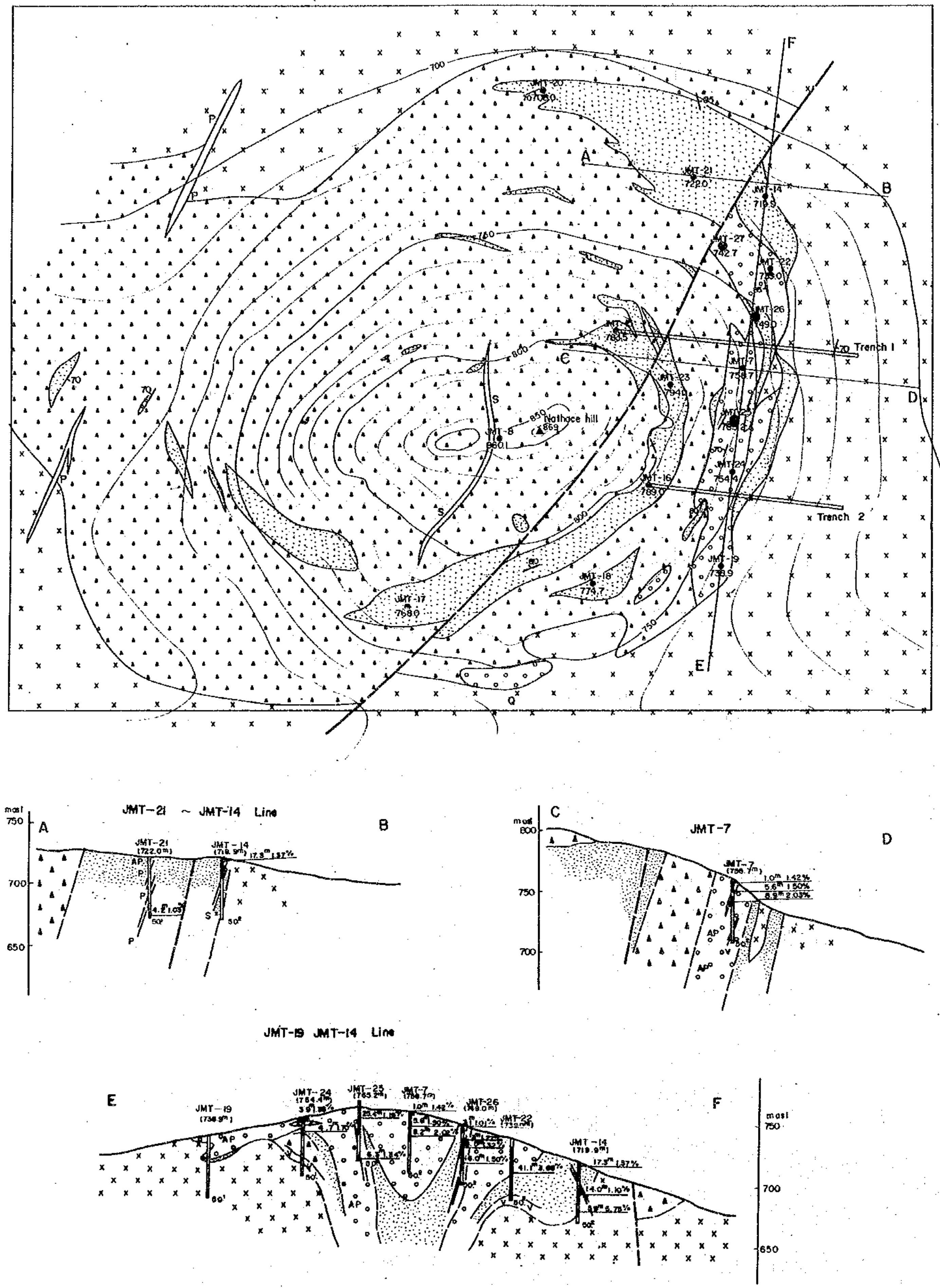
In table 11, are shown ore reserves and grade of P, P_2O_5 and REO for each body (Fig. 15).

As in the case of REO contents, it is impossible to compare the ore reserves of phosphorus with those of other mines.

The grade of phosphorus represented as P_2O_5 is 17.0%, higher than the value of Araxa Mine (P_2O_5 15.01%), suggests that the body has high potential for phosphorus deposits possible to be exploited.

Tab.11 Calculation of ore reserves (P), Tundulu

Block No.	JMT	(m^2) Area	(m) Average Hight	(t) Ore Reserves	Grade (%)		
					P	P_2O_5	REO
P1	7, 25, 26, 27	5,560	28.6	477,050	7.4	17.0	1.1



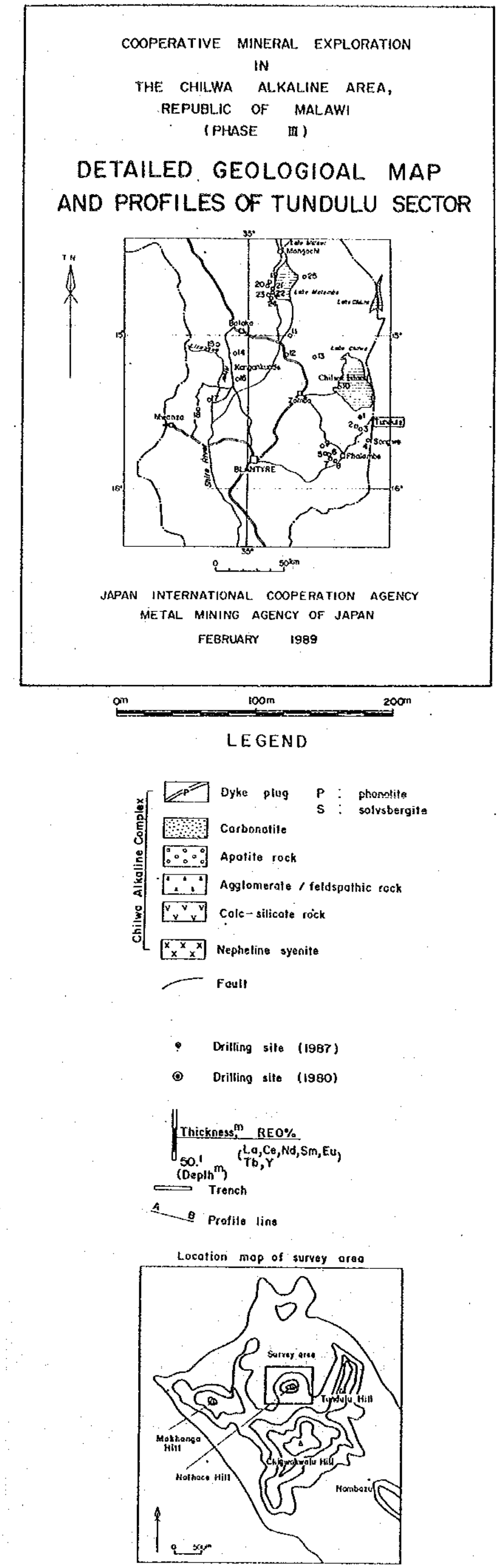


Fig. 13 Detailed geological map and profiles of Tundulu sector

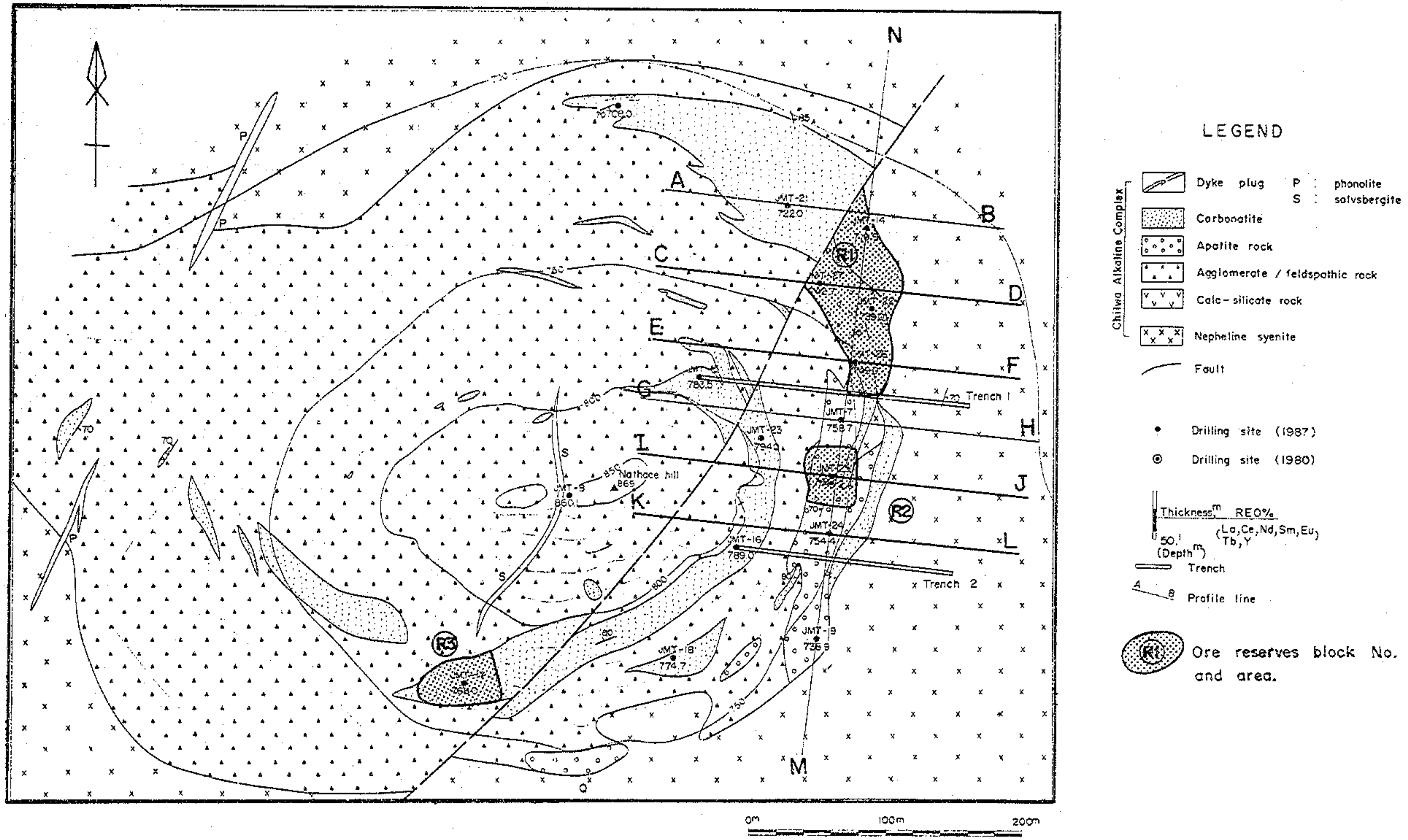


Fig.14 - 1 Geological section of drill holes and map of ore reserves (REO), Songwe
-Plain-

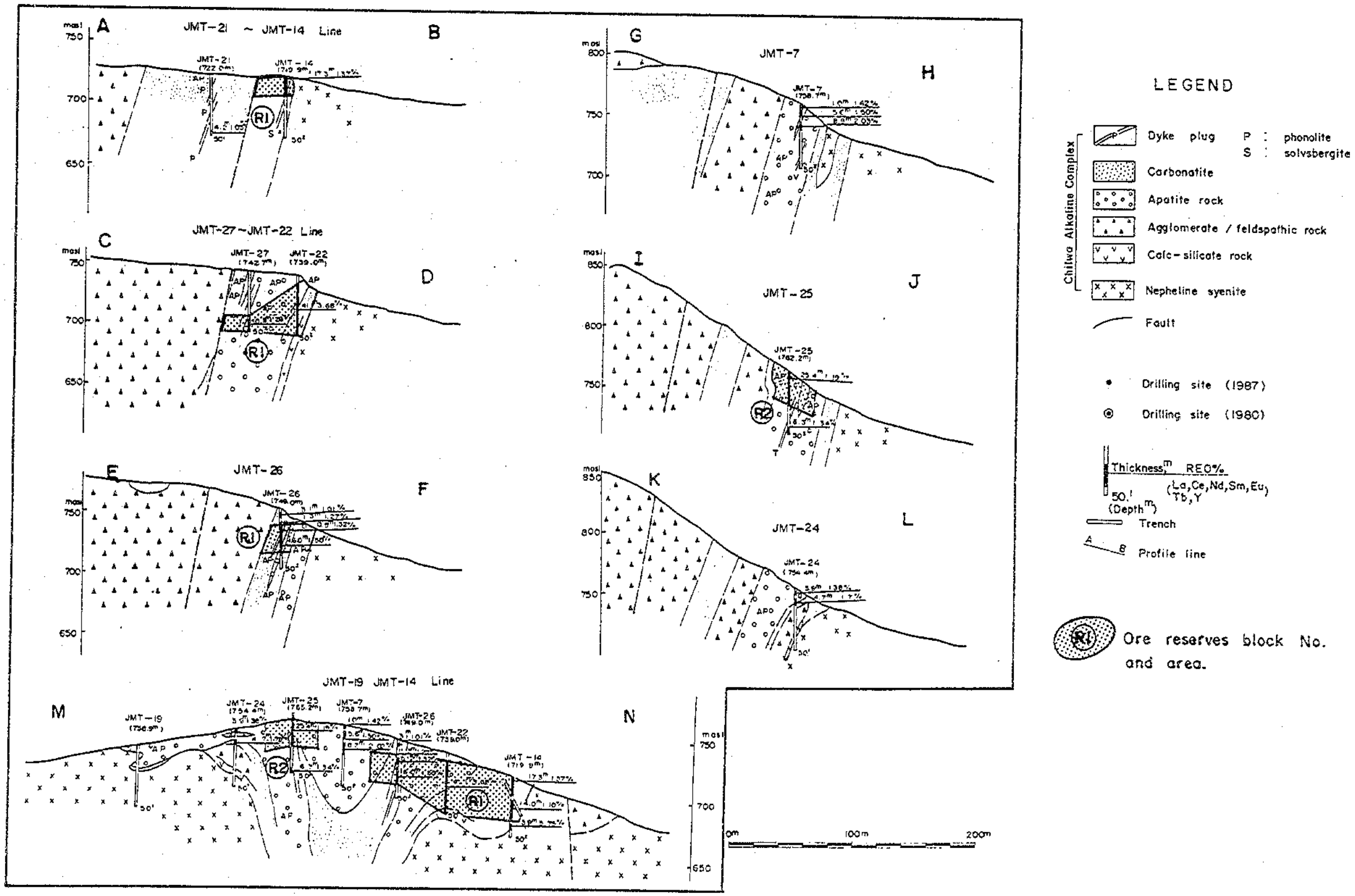


Fig. 14 - 2 Geological section of drill holes and map of ore reserves (REO), Tundulu
- Section -

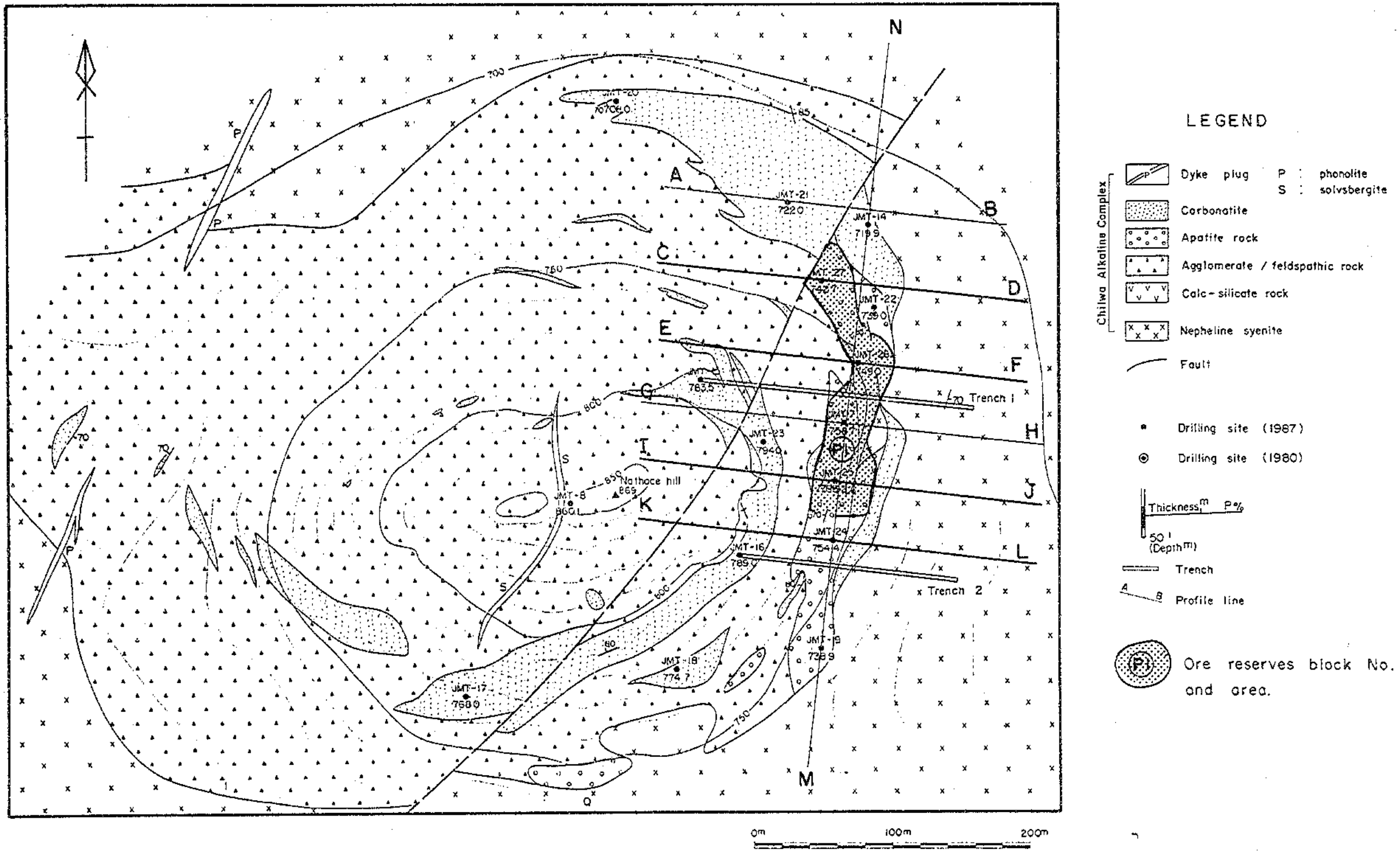


Fig. 15 - 1 Geological section of drill holes and map of ore reserves (P), Tundulu
- Plain -

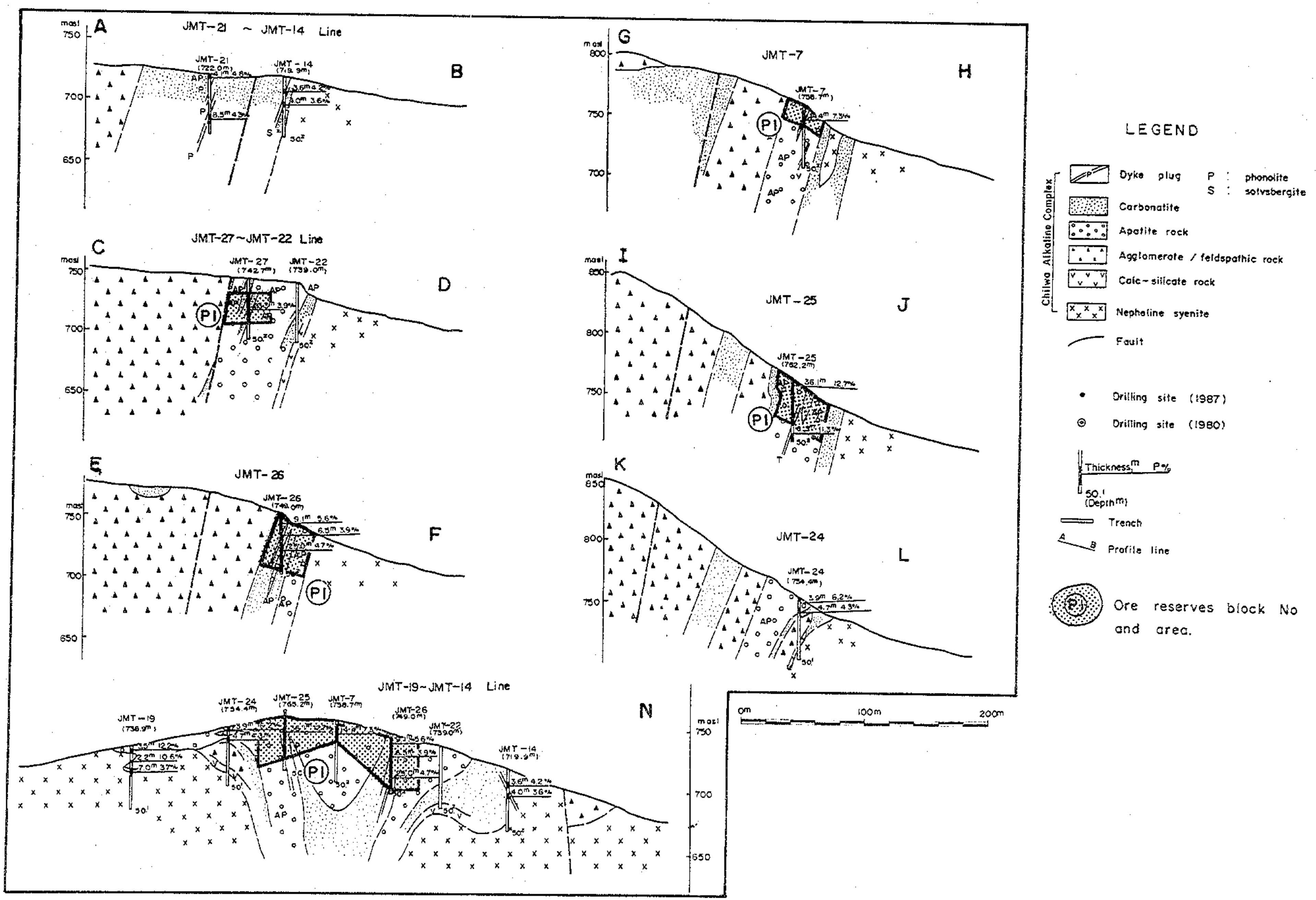


Fig. 15 -2 Geological section of drill holes and map of ore reserves (P), Tundulu
- Section -

Chapter 3 Chilwa Island sector

3-1 Method of the survey

During the third phase, geological, geochemical and drilling surveys have been conducted.

The published topographic maps of 1/50,000 in scale were enlarged to make topographic maps of 1/5,000 in scale.

Route survey was carried out by using the enlarged maps. The outcrops of mineralized zones were determined by using a tape and a pocket-compass. The results were put on the route maps of 1/2,000 in scale. Trench survey was done under the scale of 1/200. Results were drafted on the geological map of 1/5,000 in scale.

Geochemical and geological surveys were performed at the same time. As a principle, samples were collected from carbonatites. Collected samples were chemically analyzed and the results were processed and analyzed statistically by computer to estimate the geochemical anomaly.

Drilling survey was performed using small drilling rigs to collect cores from the depth less than 50m. The results of core-observation were put on the geological log of 1/200 in scale. Samples of carbonatites were collected for chemical analysis to determine REE and phosphorus contents.

Contents of the survey are shown in Tab. 12.

Tab.12 Contents of survey, Chilwa Island

Geological and geochemical survey		Drilling servey	
Area	6 km^2	No. of holes	32
Route survey	20 km	Total length	1,606.4 m
Trench survey	600 m	Inclination	-90°
Assay of geochemical samples	151 pcs	Assay of ore samples	322 pcs
Microscopic observation (Polished thin section)	32 pcs	Assay element:	
X-ray diffractive analysis	15 pcs	La, Ce, Nd, Sm, Eu, Tb, Nb, Sr,	
EPMA	5 pcs	Y, P (10 elements)	
Whole rock analysis	20 pcs		
Isotope analysis	6 pcs		

3-2 Geology (Fig. 16, 17)

Constituent rocks of this sector are as follows.

Age	Rocks
Late Jurassic to early Cretaceous	"Chilwa-Alkaline Province" Carbonatites (sovitic, ankeritic, and sideritic) Breccias (agglomerate, felspathic breccia) Nepheline syenite Dykes (phonolite, trachyte, nephelinite, lamprophyre etc.)
Late Precambrian to early Cambrian	Gneisses and syenites

Late Precambrian to early Cambrian basement rocks of gneisses and syenites are distributed in the outermost part of the sector and have undergone intense fenitization.

Gneisses are gray to grayish green in color, composed mainly of K-feldspar, plagioclase, quartz, clinopyroxene, common hornblende and biotite. Accessory minerals are apatite, ilmenite and magnetite.

Syenites have coarse-grained grayish K-feldspar and fine-to medium-grained clinopyroxene, plagioclase and quartz. Accessory minerals are apatite, pyrite and magnetite.

Igneous rocks of "Chilwa Alkaline Province" are developed throughout the island showing a ring structure, where the lithofacies are changed, from the outermost side inward, breccias, sovitic carbonatites, ankeritic and sideritic carbonatites. The diameter of the ring is approximately 2 km.

Nepheline syenite occurs around Michulu and Chinyombi Hills, situated in the northwestern part of the sector. It is leucocratic to pale pink in color, showing medium-grained equigranular texture.

Breccias occur as a small body in the carbonatite and as a layer of

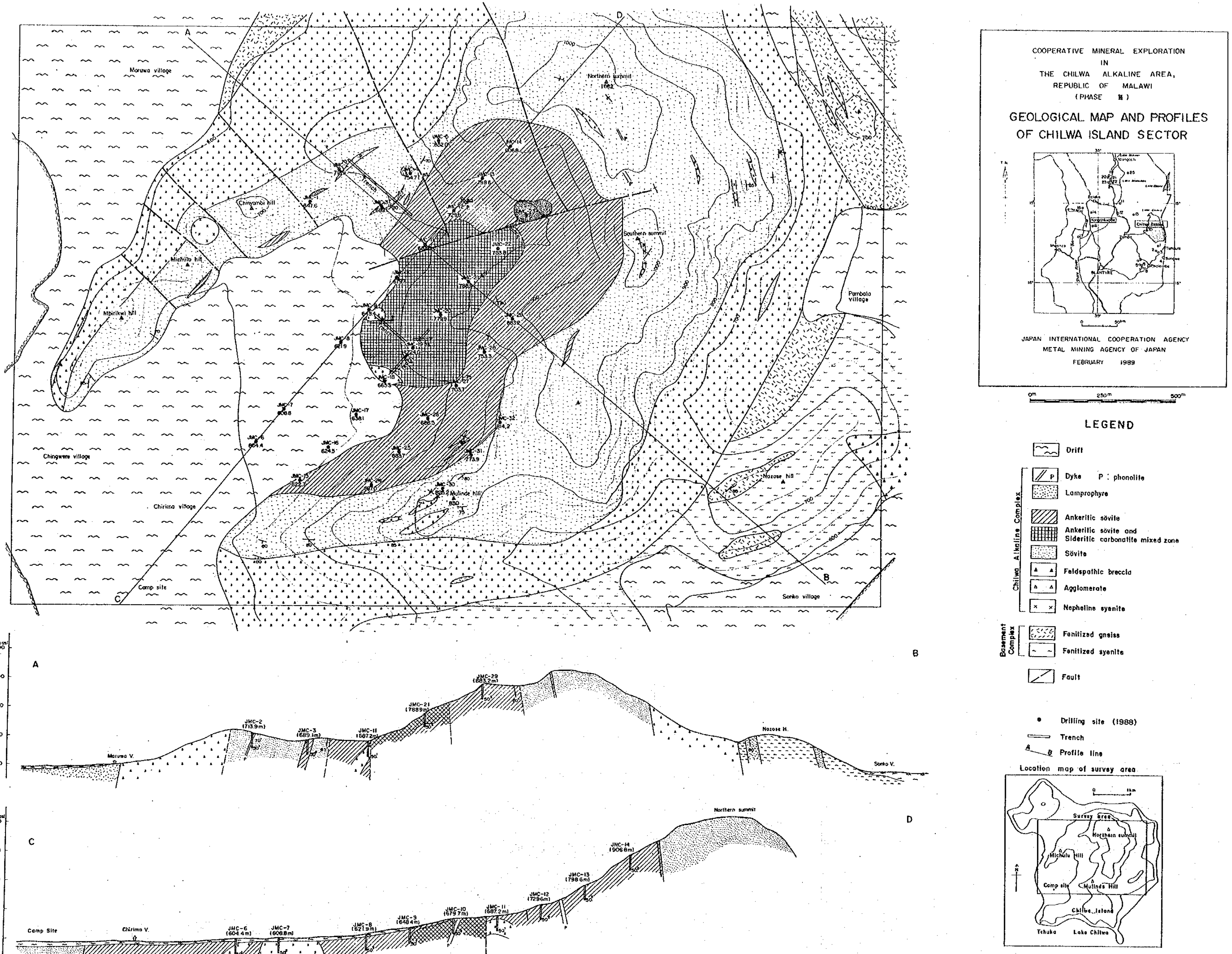


Fig.16 Geological map and profiles of Chilwa Island sector

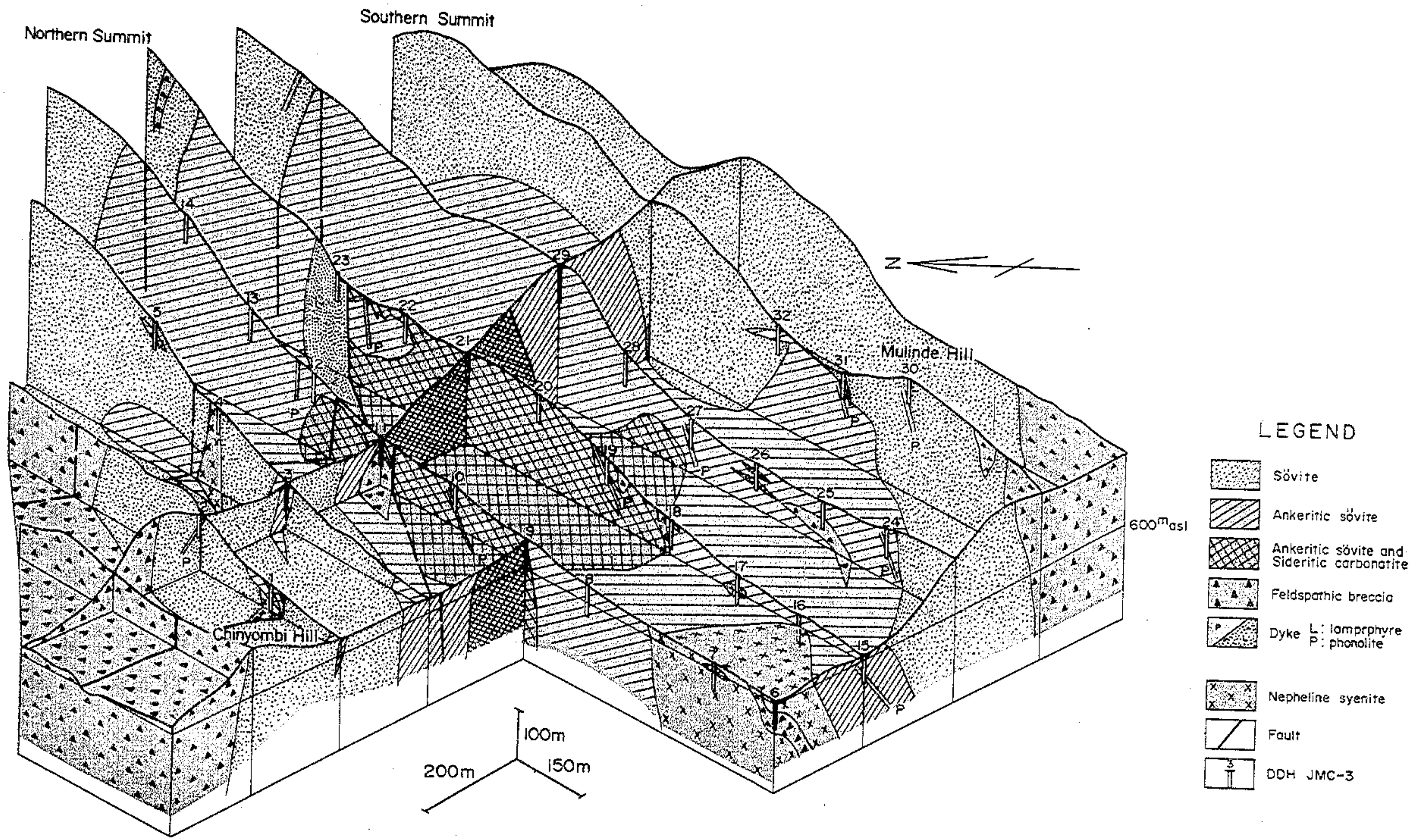


Fig. 17 **Panel diagram of the Chilwa Island carbonatite complex**

100m to 700m width along boundary between carbonatite and basement rocks. Breccias are classified into feldspathic breccia and agglomerate and the former is predominant in the sector.

Those rocks found in and adjoining to carbonatite tend to undergo carbonitized alteration. They are reddish brown to dark brown in tint and often intruded by small veins of dark manganese minerals. Breccias with interstitial carbonate always have diameter ranging from several centimeters to several meters.

Carbonatites in this sector are classified into sovitic, ankeritic and sideritic. Sovitic carbonatite is developed on and around the top of the Island from Mbirikwi, Michulu and Chinyobi Hills through Northern and Southern summits to Mulinde Hill.

Sovitic carbonatite is mainly composed of medium- to coarse-grained whitish to grayish calcite. Around Chinyombi Hill it is rich in pyroxenes and is gray to dark gray in color. Apatite, fluorite and pyrite are found as accessory minerals in places. X-ray powder diffraction analysis, has shown pyrochlore, synchysite, strontianite and apatite. This carbonatite shows a ring structure, dipping steeply outward.

Ankeritic and sideritic carbonatites are developed in the inner side of sovitic carbonatite, showing a ring structure with 1km diameter centered in the central part of Chilwa Island. The outer part of the ring is constituted by ankeritic and the inner part by mixed zone of sideritic and ankeritic ones. Ankeritic carbonatite is medium- to fine-grained and dark gray to dark brown or yellowish brown in color. Fine-grained pyrite and fluorite are visible. Main constituent minerals are ankerite and calcite and X-ray powder diffraction examination has detected bastnaesite, calkinsite, strontianite, synchysite, pyrochlore, betafite and apatite.

Dyke rocks are phonolite and lamprophyre. The former is several meters in width and the latter is found in the scale of 50m X 100m around JMC-23.

The geological structure of rocks of "Chilwa-Alkaline Province" is characterized by a ring structure.

Based upon the analyses of distribution pattern of stress, Garson et al. (1958) has assumed that the igneous activity occurred at three places of around 1,700m, 1,000 and 300m below the ground surface, each of them are arranged vertically.

3-3 Results of geochemical survey

Geochemical samples collected were mostly carbonatites. 151 samples were collected and were assayed for 10 elements. The elements assayed and their detectable limit of each element are shown in below.

Detectable limits

(ppm)

Element	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P
Limit	1	2	5	0.1	0.1	0.1	10	1	10	10

When histograms of the analyzed values of this sector are examined, most of the elements show the lognormal distributions rather than the normal distribution. Therefore, the values are changed into logarithm to be statistically analyzed and processed by computer.

3-3-1 Statistical value

Statistical values of each element and REO of this sector as well as the crustal abundance are shown in Tab. 13.

Averaged contents of nearly all elements analyzed in carbonatite here have over ten times higher than the crustal abundance.

It suggests that these 10 elements can be used effectively as pathfinder element of carbonatites in Chilwa Island sector.

Tab.13 Statistical values of geochemical survey, Chilwa Island

(ppm)

Element	Rock Type	No. of Samples	Max.	Min.	Geometrical Mean (M)	M+1S	Abundance (Earth Crust)
La	Carbonatite	117	29505	63	1309	4033	25
	Others	34	6163	51	512	1871	25
Ce	Carbonatite	117	33400	95	2544	7543	81
	Others	34	14979	79	968	3942	81
Nd	Carbonatite	117	8031	16	845	2482	20
	Others	34	5426	14	313	1531	20
Sm	Carbonatite	117	1233	0.05	87.9	680	4
	Others	34	971.5	0.05	46.4	394	4
Eu	Carbonatite	117	292.5	1	31.0	80	0.8
	Others	34	170.1	0.05	10.9	81	0.8
Tb	Carbonatite	117	87.2	0.05	2.7	35	0.5
	Others	34	59.5	0.05	1.3	20	0.5
Nb	Carbonatite	117	9155	0.5	121	1207	20
	Others	34	2539	6	214	857	20
Sr	Carbonatite	117	15088	116	3181	7823	300
	Others	34	11782	64	1529	5223	300
Y	Carbonatite	117	947	24	173	360	38
	Others	34	818	20	110	294	38
P	Carbonatite	117	61403	34	2046	8723	900
	Others	34	164631	206	2672	9467	900
REO	Carbonatite	117	83009	249	6186	17863	
	Others	34	31762	251	2457	9531	

3-3-2 Correlation of the elements

Correlation coefficient of each element in this sector is shown in Tab. 14.

Pairs of elements of extremely strong correlation having correlation coefficient over than 0.8 are (La, Ce), (La, Nd), (La, Eu), (Ce, Nd), (Ce, Eu), (Nd, Eu), (Nd, Y) and (Eu, Y). All of them are combination of REE.

As such REE minerals as bastnaesite, calkinsite and synchysite are recognized from this sector. It is considered that Sm, Eu and Nd replace parts of La and Ce in the above-shown minerals.

Tab.14 Correlation coefficients of elements, Chilwa Island

AREA: C (N of cases: 151)

Correlations:	logLa	logCe	logNd	logSm	logEu	logTb	logNb	logSr	logY	logP
logLa	1.00									
logCe	.99	1.00								
logNd	.95	.97	1.00							
logSm	.71	.75	.77	1.00						
logEu	.81	.84	.89	.73	1.00					
logTb	.49	.51	.54	.41	.55	1.00				
logNb	-.35	-.36	-.36	-.32	-.25	-.26	1.00			
logSr	.36	.37	.42	.21	.40	.25	.12	1.00		
logY	.77	.80	.83	.73	.81	.54	.26	.38	1.00	
logP	.12	.13	.15	.08	.17	.20	. 2	.60	.27	1.00

3-3-3 Distribution of anomalies

The following methods are used to select geochemical anomalous values in Chilwa Island sector.

The thresholds and anomalous are defined as :

the thresholds = M + 1S

the anomalous values ≧ M + 1S

where M: mean value of elements

S: standard deviation

The thresholds and anomalous values are shown in Tab. 13 and their distribution is mapped in Fig. 18.

It is inferred that ankeritic carbonatite and mixed zone of ankeritic and sideritic ones indicate anomalous values of REE and Sr. While Nb-anomaly is found in sovitic carbonatite and P-anomaly in sovitic and ankeritic carbonatites.

Therefore, it is concluded that the central part occupied by ankeritic carbonatite and its mixed zone with sideritic carbonatite have higher potential for REE, while the outer part occupied by sovitic carbonatite for Nb and P.

3-4 Drilling survey

As a result of the first phase survey, Chilwa Island sector has been selected as a sector with high potential for of carbonatite deposits.

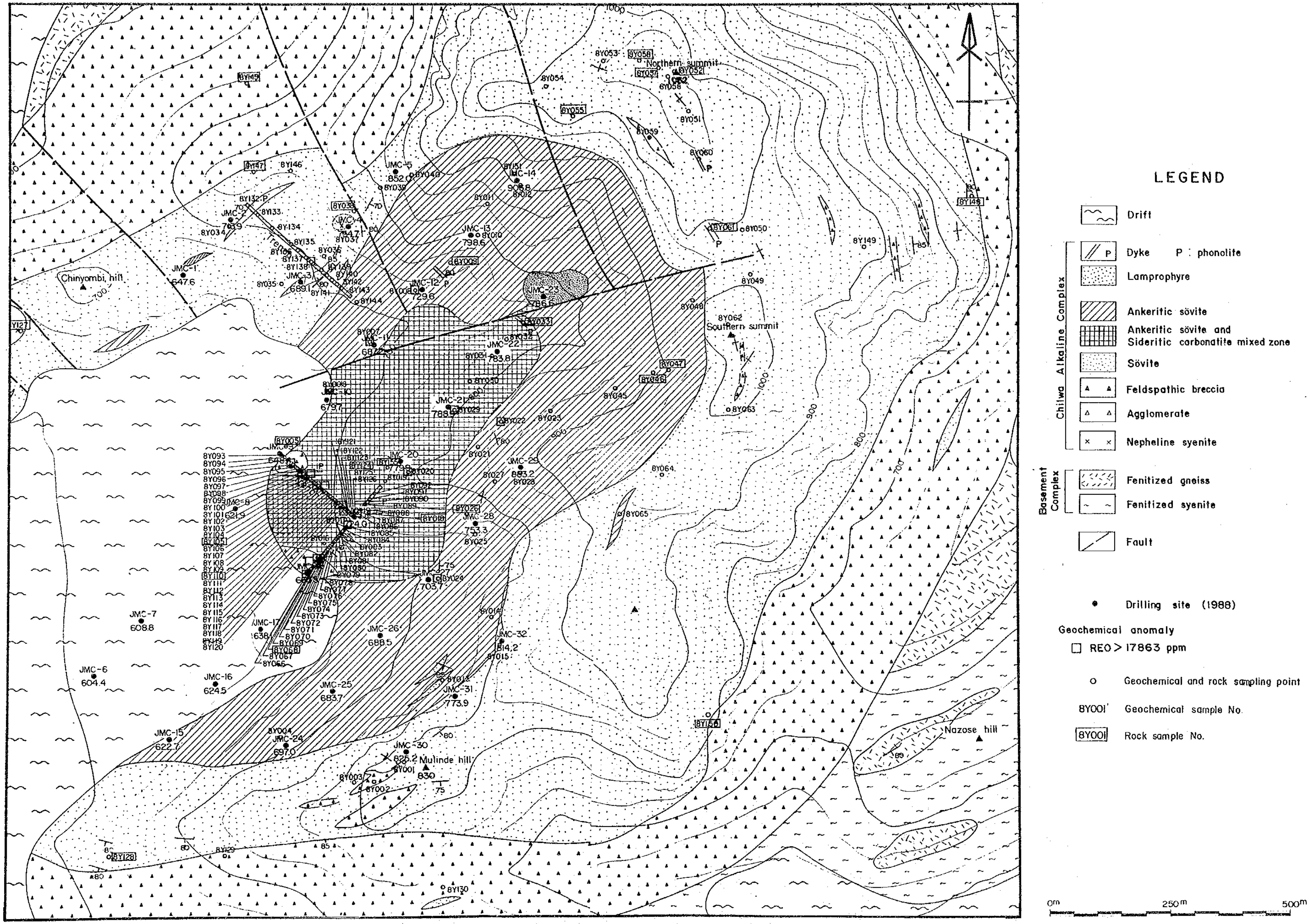


Fig. 18 - 1 Distribution of geochemical anomalies, Chilwa Island (REO)

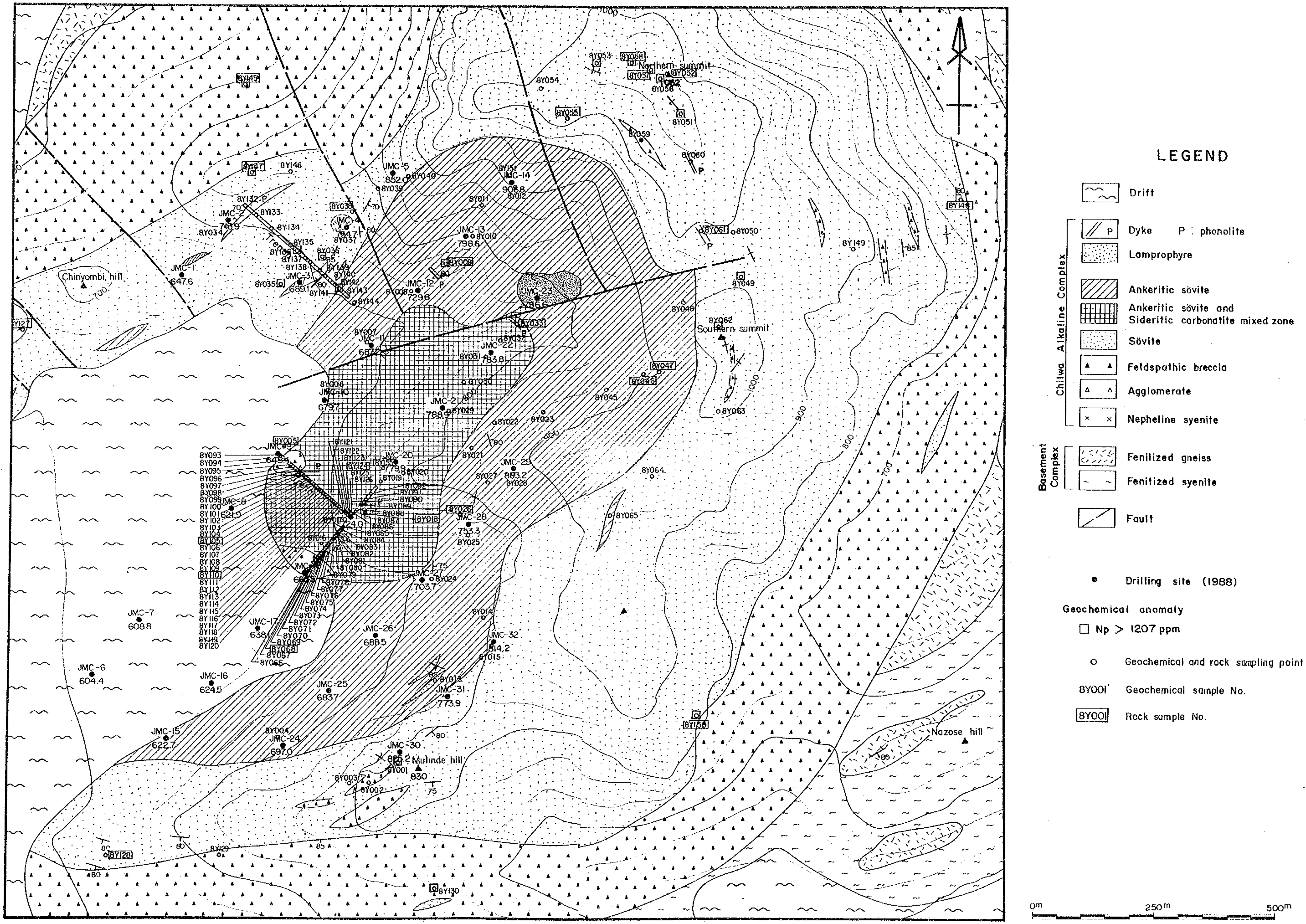


Fig. 18-2 Distribution of geochemical anomalies, Chilwa Island (Nb)

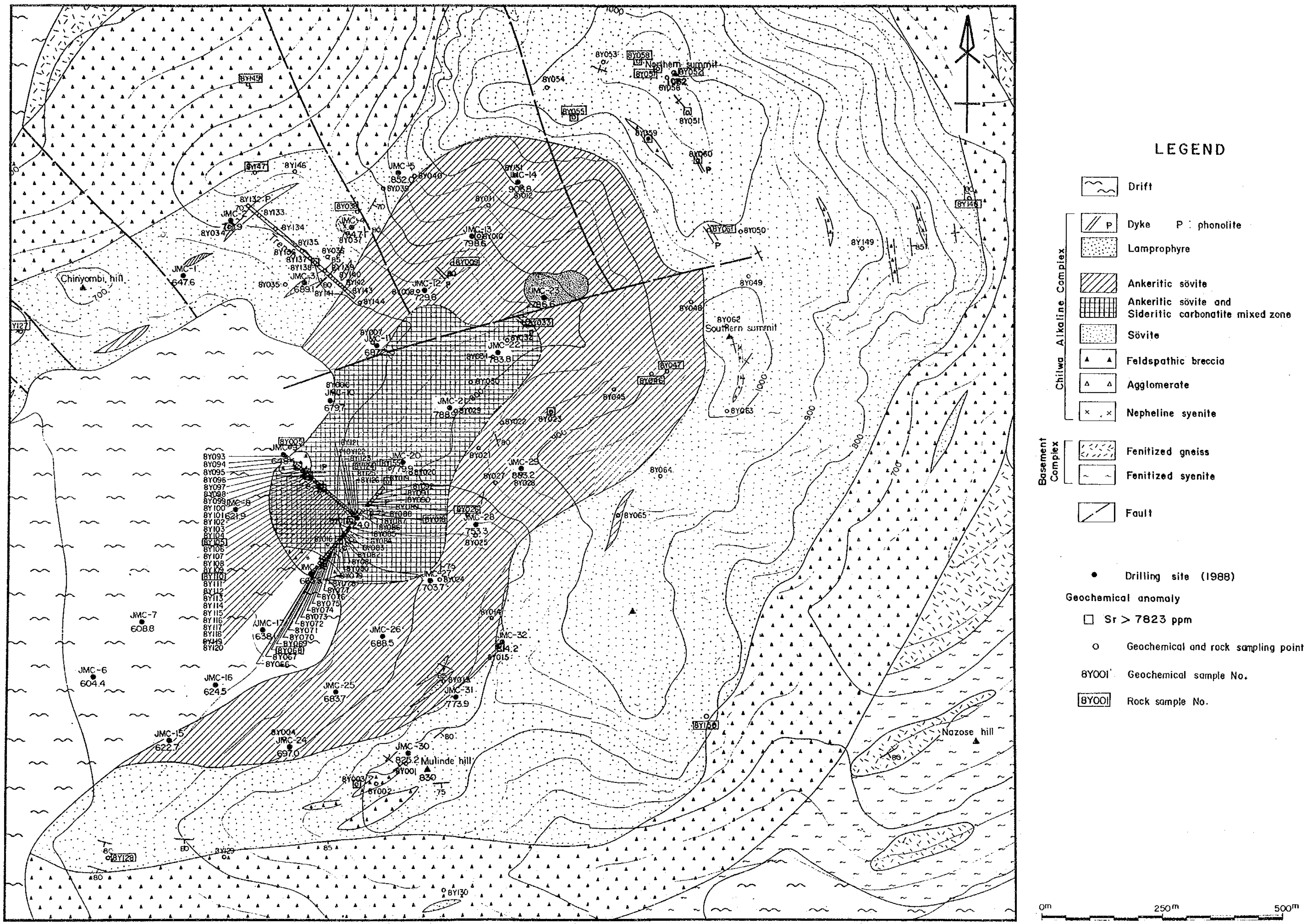


Fig.18-3 Distribution of geochemical anomalies, Chilwa Island (Sr)

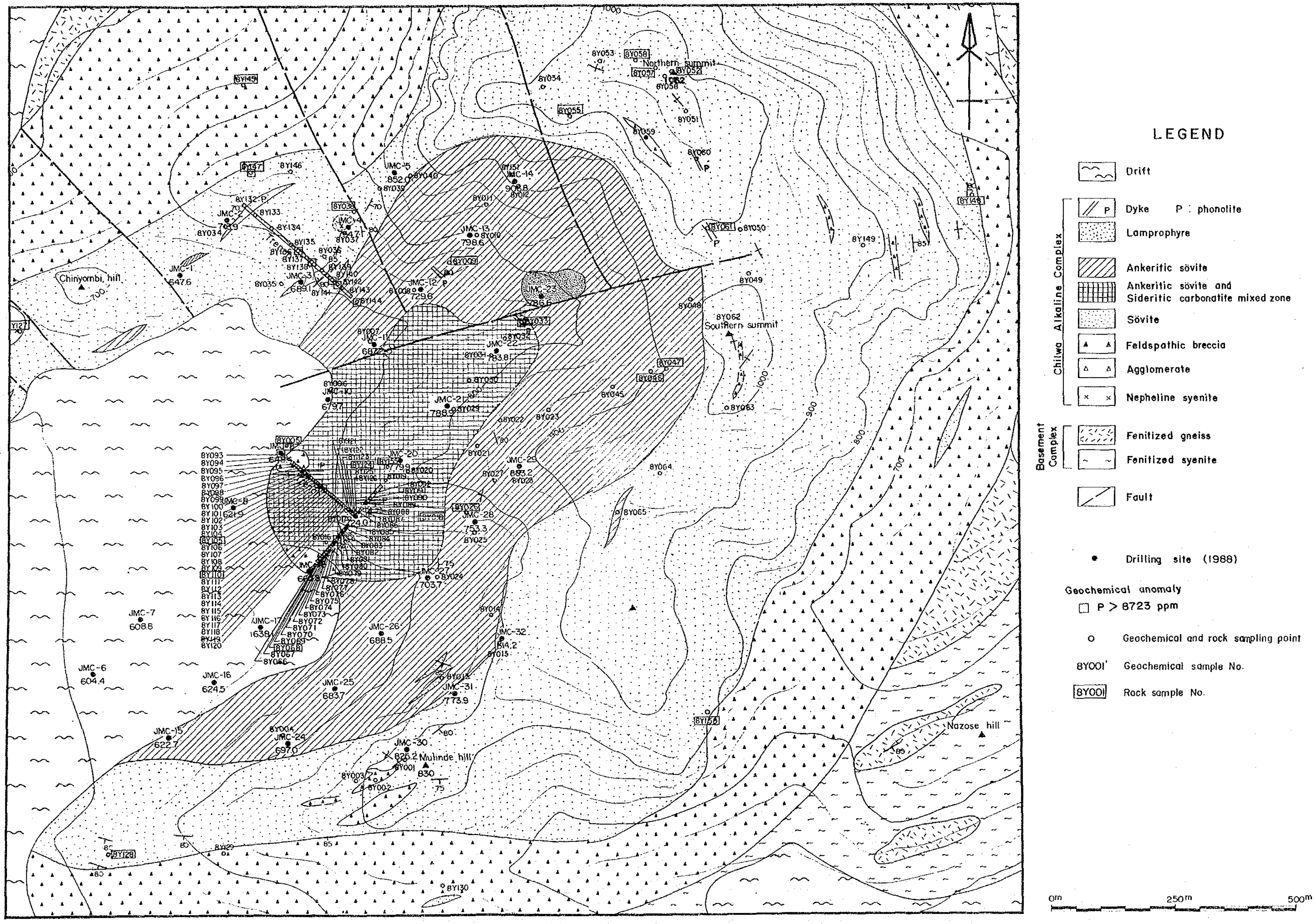


Fig.18-4 Distribution of geochemical anomalies, Chilwa Island (P)

Drilling was performed to clarify how mineralized zone occur in carbonatites in this sector.

3-4-1 Outline of drilling

Whole set of drilling rigs are transported to the survey area from Tundulu sector. Operations were performed in the same way as in Songwe and Tundulu sectors.

Contents of the drilling are as follows:

No. of drill holes	Hole length	Core length	Core Recovery except soils	No. of analyzed samples
32	1606.4m	1,391.85m	93.0%	322

Drilling covers 81 days, from August 6 to October 25.

3-4-2 Drilling procedure

Drilling rigs were transported from Nathace in Tundulu sector to Kachulu harbor on the Lake Chilwa, using trucks of 4 and 11 tons burden. From Kachulu harbor to Tchuka harbor on Chilwa Island, they were transported using midget craft, and then to the camp by human power.

Setting up of rigs was firstly made at JMC-26. Drilling in Chilwa Island sector was performed in the following order of site number, JMC-6, 15, 7, 16, 17, 25, 18, 24, 26, 30, 27, 31, 19, 32, 20, 28, 21, 29, 23, 22, 13, 12, 14, 4, 5, 2, 3, 1, 11, 10, 9 and 8. Location of drilling sites is shown in Fig. 19.

Transport routes of one meter wide were constructed from site to site, total length reached 7,000m. Construction of the routes and land readjustment around each site was performed by human power as in the cases of Songwe and Tundulu sectors.

Drilling through surface soil was performed using Metal shoe (73mm in diameter), and after reaching hard rock, diamond shoe (73mm in diameter) was used to set BW casing pipe. A diameter of diamond bit was 56mm at the bottom.

The progress of the operation at each drill hole is summarized in performance of the drilling.

3-4-3 Geology and mineralization of drill holes

Drilling was performed, from outcrop at the surface to about 50m depth, mainly aiming at clarifying mode of occurrence of useful minerals rich in REE to evaluate the potential as carbonatite ore deposits.

Geology of each drill hole is shown in Fig. 20. Chemical compositions and REO of core samples are shown in Appendix 2.

REE-mineralized zones defined as having over 1.0% REE oxides content are listed in Tab. 15. In Tab. 16, shown are phosphorus-mineralized zones where phosphorus content is over 2.2% (approximately 5% in P_2O_5 equivalent) and the length is over 2.0m.

In Chilwa Island sector, REE-mineralized zones are recognized at JMC-3, 10, 11, 12, 19, 20, 21, 26 and 29, where the thickness of zones are over ten meters. Description of each zone is given in Tab. 17.

Tab.17 Relationship between REO mineralized zone and geology

JMC	Depth	Thick	REO	Geology
	m m	m	%	
3	12.1 ~ 47.2	35.1	1.64	Phonolite dyke bearing ankeritic sövite with siderite
10	7.2 ~ 22.2	10.0	2.15	ditto
11	1.1 ~ 11.7	10.6	1.54	Feldspathic breccia and ankeritic sövite
12	2.2 ~ 50.2	48.0	1.48	Ankeritic sövite
19	1.0 ~ 18.3	17.3	1.46	Ankerite bearing sideritic carbonatite
20	0.4 ~ 21.4	21.0	2.05	Sideritic carbonatite and ankeritic sövite
21	21.6 ~ 46.5	24.9	1.33	ditto
26	15.0 ~ 47.9	32.9	1.26	Sideritic carbonatite, ankelitic sövite and feldspathic breccia
29	0.4 ~ 10.4	10.0	1.28	Ankeritic sövite

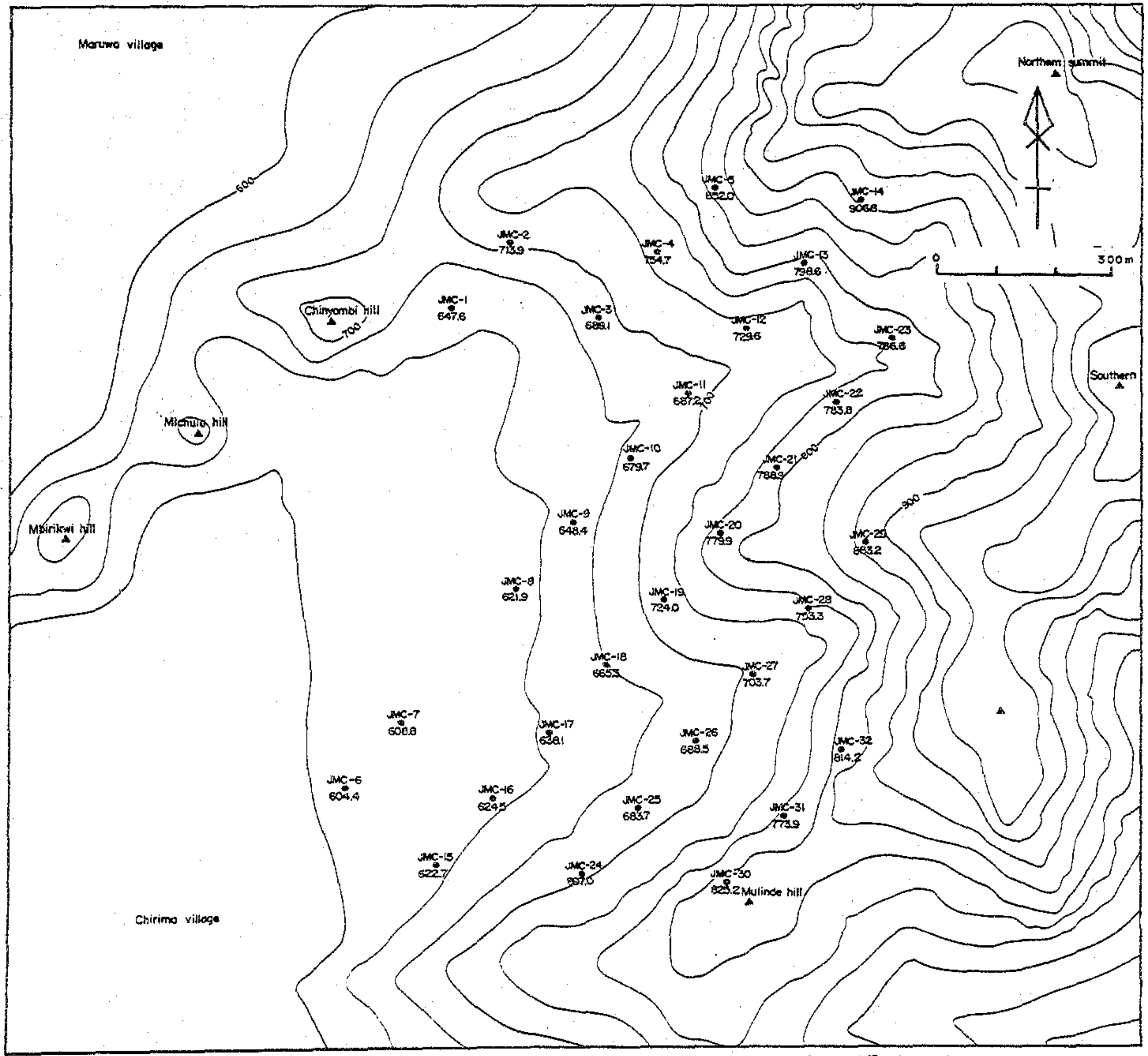


Fig. 19 Location map of drilling sites, Chilwa Island

LEGEND

• Drilling site (1988)

Performance of the drilling, Chilwa Island (1)

Hole	Drilled length (m)	Core length	Core recovery except soil (%)	Working period M.D. ~M.D	Bit size φ 73 mm Depth (m)	Bit size φ 73 mm Perfor mance of the drilling	Bit size φ 56 mm Depth (m)	Bit size φ 56 mm Performance of the drilling
JMC− 1	50.20	39.70	91.7	10.13~10.14	6.90	0~6.9m drilling with metal shoe, Using TK-60, Installation of BW Casing pipe	43.30	Drilling with diamond bit, Using TK-60, 33.1m Escape of whole water
JMC− 2	50.10	46.20	93.5	10. 8~10.10	1.60	1.6m drilling with metal shoe, Using TK-60, Installation of BW Casing pipe	48.50	Drilling with diamond bit, Using TK-60, 6.4m Escape of whole water
JMC− 3	50.30	46.20	93.9	10.11~10.12	1.70	0~1.1m drilling with metal shoe, 1.1m~1.7m drilling with diamond bit, Using TK-60, Installation of BW casing pipe	48.60	Drilling with diamond bit, Using TK-60, 42.9m Escape of whole water
JMC− 4	50.20	39.70	85.0	10. 3~10. 5	3.50	3.5m drilling with metal shoe, Using TK-60, Installation of BW Casing pipe	46.70	Drilling with diamond bit, Using TK-60, 26.6m Escape of whole water
JMC− 5	50.30	39.0	82.1	10. 6~10. 8	2.80	2.8m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	47.50	Drillng with diamond bit, Using TK-60, 2.8m~13.3m Reaming and installation of BW casing pipe, 39.0m Escape of whole water
JMC− 6	50.10	31.80	82.6	8. 6~ 8. 8	10.50	10.5m drilling with metal shoe, Using TK-60, Installasion of BW casing pipe	39.60	Drilling with diamond bit, Using TK-60, 11.3m Escape of whole water
JMC− 7	50.20	34.10	84.2	8.11~ 8.13	9.70	9.7m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	40.50	Drilling with diamond bit, 9.7m~12.8m Reaming and installation of BW casing pipe, 15.3m Escape of whole water
JMC− 8	50.30	34.70	84.8	10.22~10.25	9.40	9.4m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	40.90	Drilling with diamond bit, Using TK-60, 32.5m Escape of whole water
JMC− 9	50.10	38.10	85.8	10.20~10.22	5.70	5.7m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	44.40	Drillng with diamond bit, Using TK-60, 43.5m Escape of whole water
JMC− 10	50.30	42.40	88.1	10.18~10.20	2.50	2.5m drilling with metal shoe, Using TK-60, Installation of BW casing	47.80	Drilling with diamond bit, Using TK-60, 16.2m Escape of whole water
JMC− 11	50.10	45.70	93.3	10.15~10.17	1.50	1.5m drilling with metal shoe, Using TK-60, Installation of BW casing	48.60	Drilling with diamond bit, Using TK-60, 21.1m Escape of whole water
JMC− 12	50.20	46.10	96.0	9.29~ 9.30	2.60	2.6m drilling with metal shoe, Using TK-60, Installation of BW casing	47.60	Drilling with diamond bit, Using TK-60, 4.5m Escape of whole water
JMC− 13	50.30	48.40	99.8	9.27~ 9.28	1.80	1.8m drilling with metal shoe, Using TK-60, Instllation of BW casing	48.50	Drilling with diamond bit, Using TK-60, 2.5m Escape of whole water,
JMC− 14	50.20	47.60	95.6	10. 1~10. 3	1.60	1.6m drilling with diamond shoe, Using TK-60, Installation of BW casing	48.60	Drilling with diamond bit, Using TK-60, 5.3m Escape of whole water,
JMC− 15	50.20	44.80	94.1	8. 9~ 8.11	2.60	2.6m drilling with metal shoe Using TK-60, Installation of BW casing	47.60	Drilling with diamond bit, Using TK-60, 13.5m Escape of whole water
JMC− 16	50.20	44.70	96.8	8.14~ 8.15	4.00	4.0m drilling with metal shoe, Using TK-60, Installation of BW casing	46.20	Drilling with diamond bit, Using TK-60, 15.3m Escape of whole water

Performance of the drilling, Chilwa Island (2)

Hole	Drilled length (m)	Core length	Core recovery except soil(%)	Working period M.D. ~M.D.	Bit size φ73mm Depth(m)	Bit size φ73mm Performance of the drilling	Bit size φ56mm Depth(m)	Bit size φ56mm Performance of the drilling
JMC－17	50.20	33.90	83.5	8.16 ~8.17	2.00	2.3m drilling with metal shoe, Using TK-60, Installation of BW casing	48.20	Drilling with diamond bit, 2.3m~9.6m Reaming and installation of BW, 13.4m Escape of whole water
JMC－18	50.10	45.80	98.3	8.20 ~8.22	3.50	0~3.5m drilling with metal shoe, Using TK-60, Installation of BW casing	46.60	Drilling with diamond bit, 3.5m~12.5m Reaming and installation of BW, Using TK-60, 38.7m Escape of whole water
JMC－19	50.20	48.30	98.2	9. 4 ~9. 6	1.50	1.5m drilling with diamond shoe, Using TK-60, Installation of BW casing	48.70	Drilling with diamond bit, Using TK-60, 4.5m Escape of whole water
JMC－20	50.20	49.20	98.8	9. 9 ~9.11	1.80	1.8m drilling with diamond shoe, Using TK-60, Installation of BW casing	48.	Drilling with diamond bit, Using TK-60, 2.7m Escape of whole water
JMC－21	50.30	45.80	93.9	9.14 ~9.16	1.50	1.5m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.80	Drilling with diamond bit, 1.5m~2.3m reaming and installation of BW, Using TK-60, 2.4m Escape of whole water
JMC－22	50.20	49.00	99.6	9.22 ~9.24	2.10	2.1m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.10	Drilling with diamond bit, Using TK-60, 2.5m Escape of whole water.
JMC－23	50.10	39.70	98.0	9.20 ~9.22	9.60	9.6m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	40.50	Drilling with diamond bit, Using TK-60, 16.0m Escape of whole water
JMC－24	50.30	44.30	93.7	8.22 ~8.24	3.00	3.0m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	47.30	Drilling with diamond bit, Using TK-60, 18.4m Escape of whole water
JMC－25	50.10	43.90	93.0	8.18 ~8.20	2.90	0~2.9m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	43.90	Drilling with diamond bit, 2.9m~6.4m reaming and installation of BW, Using TK-60, 25.8m Escape of whole water
JMC－26	50.20	47.25	98.0	8.26 ~8.28	2.00	2.0m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.20	Drilling with diamond bit, Using TK-60, 30.5m Escape of whole water
JMC－27	50.20	48.70	100	8.31 ~9. 1	2.00	2.0m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.20	Drilling with diamond bit, Using TK-60, 8.5m Escape of whole water
JMC－28	50.20	48.40	100	9.12 ~9.14	1.80	1.8m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.40	Drilling with diamond bit, Using TK-60, 4.2m Escape of whole water
JMC－29	50.30	48.40	97.0	9.18 ~9.19	1.60	1.6m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	48.70	Drilling with diamond bit, Using TK-60, 3.4m Escape of whole water
JMC－30	50.20	45.30	90.2	8.28 ~8.30	2.50	2.5m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	47.70	Drilling with diamond bit, Using TK-60, 19.1m Escape of whole water
JMC－31	50.20	35.00	81.0	9. 2 ~9. 4	7.00	7.0m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	43.20	Drilling with diamond bit, Using TK-60, 39.0m Escape of whole water
JMC－32	50.10	46.40	97.5	9. 7 ~9. 9	3.00	3.0m drilling with metal shoe, Using TK-60, Installation of BW casing pipe	47.10	Drilling with diamond bit, Using TK-60, 15.6m Escape of whole water

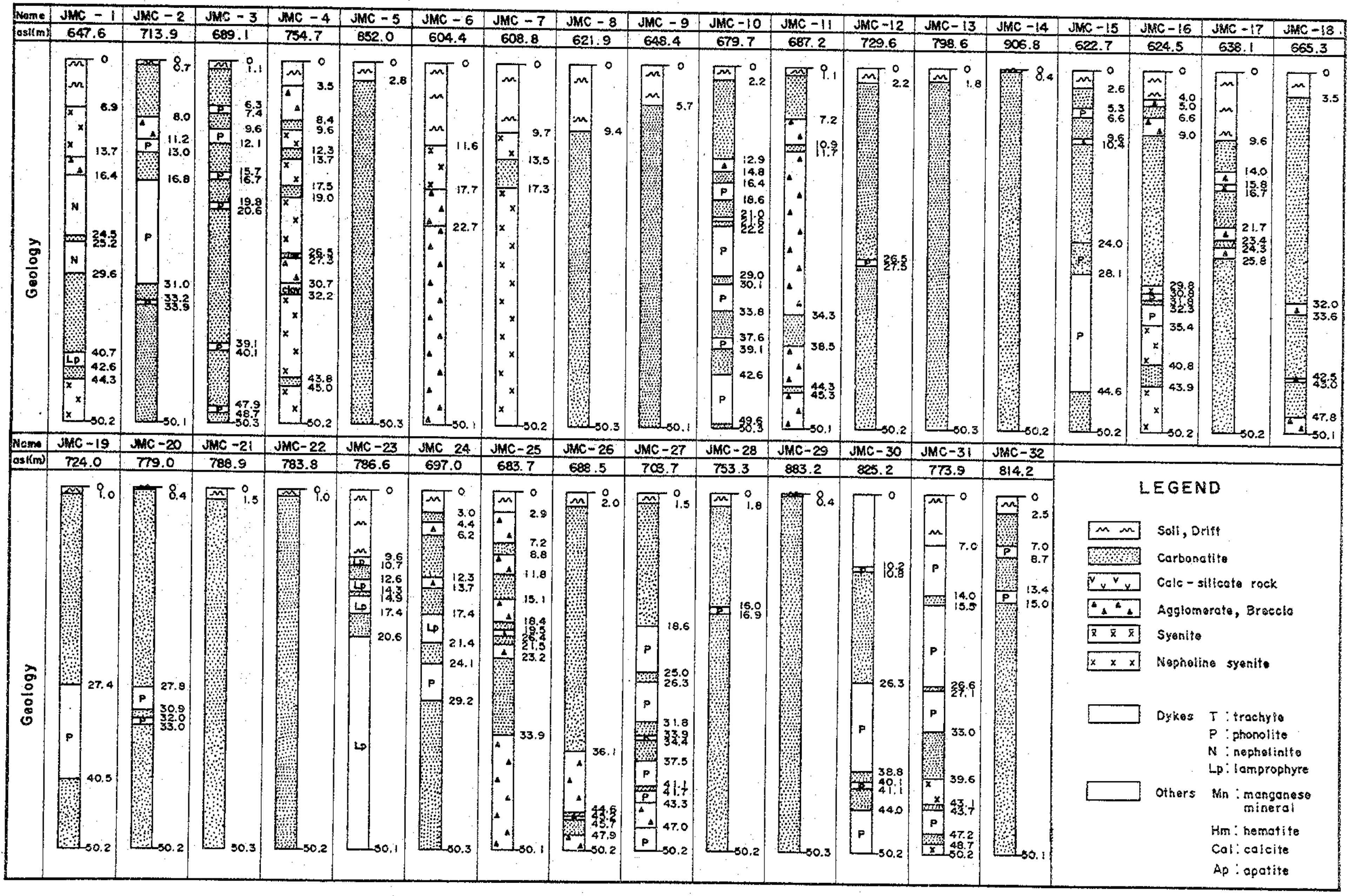


Fig.20 Compiled geologic log, Chilwa Island

Tab.15 Summary of the mineralized zone (REO>1.0%), Chilwa Island

(ppm)

Drill No.	Depth	Thick	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
JMC-3	1.1 - 4.4	3.3	4466	6007	1409	213.20	44.30	8.50	262.0	3938	227	3846.0	14854.8
	12.1 - 47.2	35.1	4763	6569	1647	303.61	68.06	15.51	528.2	5842	311	6438.6	16418.3
JMC-7	13.5 - 17.3	3.8	6176	8116	1911	318.60	58.70	20.40	90.0	3525	377	7230.0	20378.9
JMC-10	7.2 - 22.2	15.0	5627	9688	2054	267.87	43.91	13.26	310.4	6439	214	7579.7	21541.9
	33.8 - 42.6	8.8	3339	6602	1607	248.85	41.56	10.56	291.2	3578	172	3335.8	14464.2
JMC-11	1.1 - 11.7	10.6	3692	6804	1718	270.01	50.20	4.58	205.4	4566	262	6192.4	15399.2
	30.5 - 38.5	8.0	3114	4895	1240	200.71	33.81	7.32	321.5	4997	170	4494.6	11606.3
JMC-12	2.2 - 50.2	48.0	3760	6351	1715	229.74	37.41	11.12	254.8	5148	183	4817.9	14764.3
JMC-14	5.2 - 9.0	3.8	2831	4336	1233	207.20	47.50	12.90	141.0	3665	91	4608.0	10508.8
	31.4 - 36.2	4.8	2327	4222	1580	266.60	64.70	17.70	263.0	2076	133	1867.0	10329.9
JMC-19	1.0 - 18.3	17.3	2700	6344	2349	312.91	58.55	18.75	113.3	3361	351	3918.9	14594.2
JMC-20	0.4 - 21.4	21.0	5141	9006	2288	299.85	53.38	11.97	171.1	4957	283	3293.1	20541.3
	45.0 - 50.2	5.2	4430	8791	2435	291.50	51.10	15.80	239.6	6253	239	5205.0	19550.0
JMC-21	10.2 - 15.2	5.0	2652	6034	1892	250.60	49.30	21.70	302.0	6998	278	6763.0	13452.4
	21.6 - 46.5	24.9	2886	5950	1666	208.47	38.95	12.87	277.9	7395	259	6576.6	13264.8
JMC-22	1.0 - 6.8	5.8	3871	5711	1237	168.90	35.00	7.70	629.0	7733	264	5787.0	13576.7
	19.3 - 24.6	5.3	3951	6913	1758	227.10	40.00	14.50	450.0	10988	270	7409.0	15842.9
	43.9 - 47.7	3.8	3322	4808	914	117.20	18.40	14.50	331.0	2214	108	952.0	11177.8
JMC-25	11.8 - 15.1	3.3	3381	5139	1430	235.40	53.50	9.70	392.0	6389	268	5118.0	12630.5
JMC-26	15.0 - 47.9	32.9	2035	4961	2596	403.71	86.92	21.30	331.6	5477	383	4286.9	12585.8
JMC-28	26.7 - 31.7	5.0	2224	5091	2431	386.50	89.30	32.60	298.0	6330	274	10134.0	12632.3
JMC-29	0.4 - 10.4	10.0	3352	5252	1546	225.20	52.30	19.35	121.0	4349	211	3948.5	12794.8
	30.4 - 35.4	5.0	2410	4406	1678	323.80	75.80	14.70	91.0	3588	180	1736.0	10903.0
	45.4 - 50.3	4.9	1962	4111	1765	332.90	82.30	24.50	294.0	5797	255	6898.0	10241.2
Bayan Obo (China)			2171	7166	5061	567	67	17	-	-	134		20000

Tab.16 Summary of the mineralized zone (P>2.2%, Thick>2.0m), Chilwa Island

(ppm)

Drill No.	Depth	Thick	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
JMC-2	1.7 - 7.2	6.5	736	1349	348	51.80	21.30	10.00	1336.0	5369	189	32492.0	3262.0
JMC-13	22.5 - 37.9	15.4	861	1840	784	126.39	34.85	9.35	612.2	5948	252	29433.8	4700.9
JMC-15	14.3 - 24.0	9.7	778	1451	446	71.65	20.28	1.73	824.1	3318	127	21408.8	3484.4
JMC-17	30.4 - 36.3	5.9	495	1007	376	66.60	17.90	0.05	1171.0	395	86	21892.0	2462.9
	41.0 - 46.2	5.2	754	1473	472	77.70	20.70	19.30	537.0	2763	110	22540.0	3519.7
JMC-28	46.7 - 50.2	3.5	1422	2718	1096	175.90	55.80	29.50	486.0	8471	629	52071.0	7385.1
JMC-32	20.1 - 26.5	6.4	1329	2272	645	122.20	35.50	5.90	5920.0	6058	190	20038.0	5532.0

These mineralized zones are not usually found in sovitic carbonatite but in ankeritic and sideritic carbonatites (Fig. 21).

Main constituent minerals in the zones are bastnaesite, synchysite and kalkinsite. Such rare metal minerals as strontianite and pyrochlore are also often associated. As compared with the grade of ores from Bayan Obo Mine, REO content is rather lower, but the contents of such medium REE as Eu and Tb are 1.3 and 1.9 times higher, respectively.

Phosphorus-mineralized zone is recognized at JMC-13. The core samples with continuous mineral indication are from a 15.4m long zone between 22.5m and 37.9m. Its phosphorus content is 2.94%. At other drill holes, the zones are smaller-scaled than that at JMC-13.

3-5 Discussion

Geology and characteristics of carbonatites in Chilwa Island have been summarized as follows (Garson et al., 1958; JICA and MMAJ, 1988):

1. The area of 3.5km X 2.6km of Chilwa Island is occupied by Alkaline rocks and carbonatites.
2. Basement rocks near carbonatites have undergone intense fenitization.
3. Carbonatites body shows a ring structure, which consists of breccias, sovitic, ankeritic and sideritic carbonatites from outer side inward.
4. In the ring, the stage of igneous activity of carbonatites becomes younger inward.
5. The igneous activity occurred at three places of around 1,700m, 1,000 and 300m below the ground surface, each of them is arranged vertically.

During the third phase, geological, geochemical and drilling surveys were carried out together with laboratory experiments. The purpose of this phase survey was to elucidate the geological conditions and petrogenesis of the carbonatite body in Chilwa Island.

Through the field works, carbonatites are preliminarily classified into sovitic, ankeritic and sideritic. The comparison among the results of field observation, microscopic analysis and X-ray diffraction examination for these three types are shown in Tab. 18.

It has been clarified that sovitic and ankeritic carbonatites contain dolomite and that magnetite and goethite are abundant in sideritic one. Siderite is considered to be partly altered to goethite (C1901, C2606, C2609 and C2907).

As the results of previous works, central part and its adjoining part of the carbonatite body have been considered to be sideritic and ankeritic, respectively. Through the survey of this phase, however, ankeritic carbonatite is recognized in sideritic one (JMC-19, 20 and 21), thus ankeritic carbonatite where sideritic carbonatite is often associated is discriminated as mixed part of both carbonatites.

As shown before, the geological structure of Chilwa Island sector is characterized by a ring structure. Although constituent rocks in the inner part of the ring dip in rather random direction, in the outer part they tend to dip steeply outward (Fig. 22).

Minerals such as apatite (C1306) and pyrochlore (C3211 and 8Y058) were analysed by EPMA to estimate the contents of REE and other elements. As a result of the analysis, it has been clarified that apatite contains La (7.12%), Ce (13.7%) and Th (1.21%) and pyrochlore has Nb (33.1-47.4%), and Ce (1.33-2.76%).

Carbon and oxygen isotopic ratios are analyzed for carbonatites in order to elucidate the petrogenesis of these rocks.

Analyzed results for sovitic (8Y038 and 8Y058) and ankeritic ones (8Y009 and 8Y026), composed of calcite, ankerite and dolomite, are $\delta^{13}C=-4.5‰$ to $-2.4‰$ and $\delta^{18}O=+8.2‰$ to $+12.1‰$. The values are rather higher than those of apatite rocks and carbonatites in Nathace Hill, but suggest that these rocks are igneous in origin.

The result for sideritic carbonatite (8Y068 and 8Y124), though it shows no sign of containing carbonate through X-ray diffraction examination, has $\delta^{13}C=-6.6‰$ to $-6.7‰$ and $\delta^{18}O=+18.3‰$ to $+20.3‰$. Thus the rocks are inferred to have undergone alteration through contamination by meteoric water (see 4-2). It might be stated that during the alteration carbonate minerals and goethite replace siderite. The carbonate may be amorphous one.

As a result of geological, geochemical and drilling surveys of the third phase, it is inferred that ankeritic carbonatite and its mixed zone

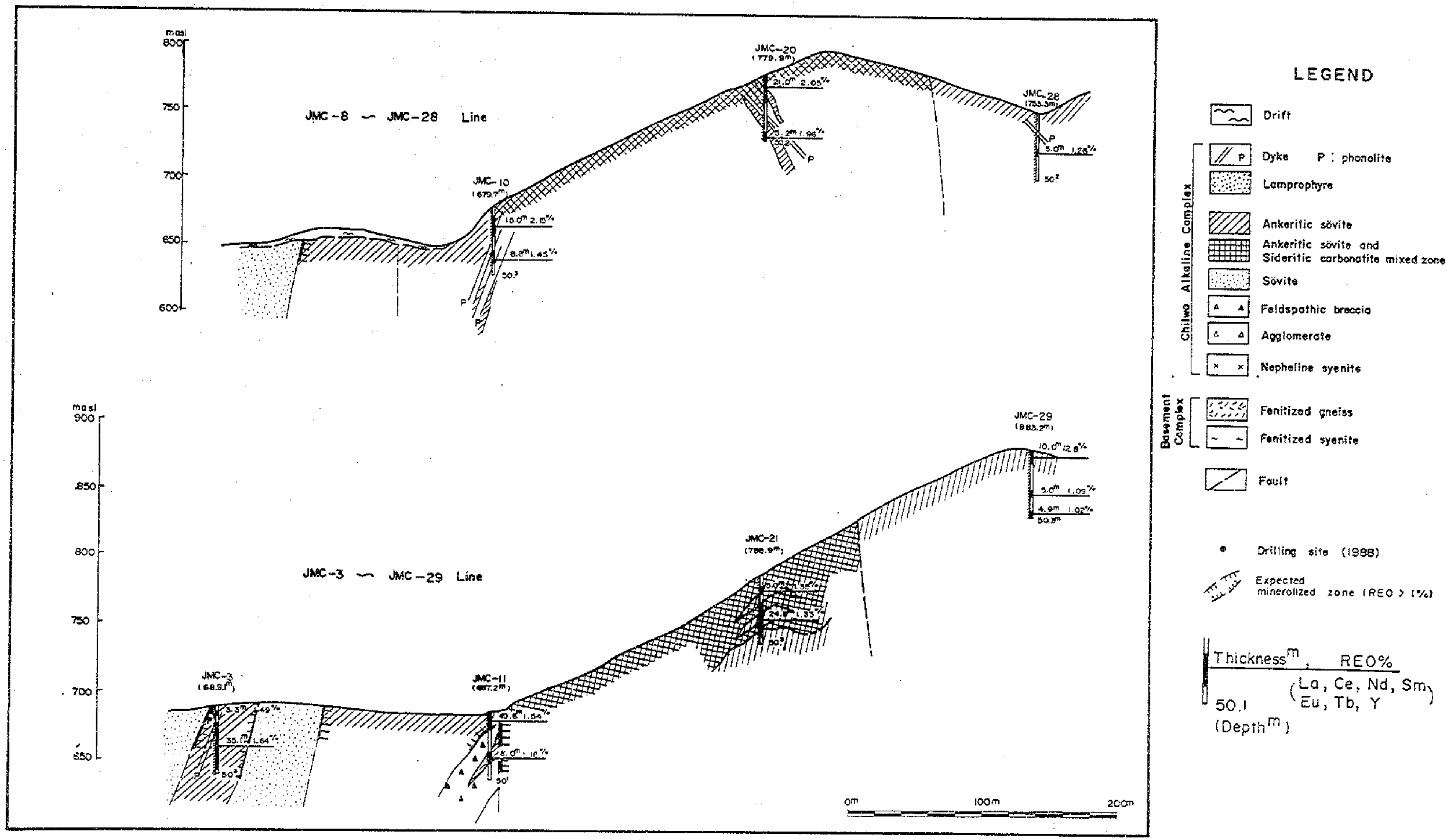


Fig.21 - 1 Geological section of drill holes, Chilwa Island

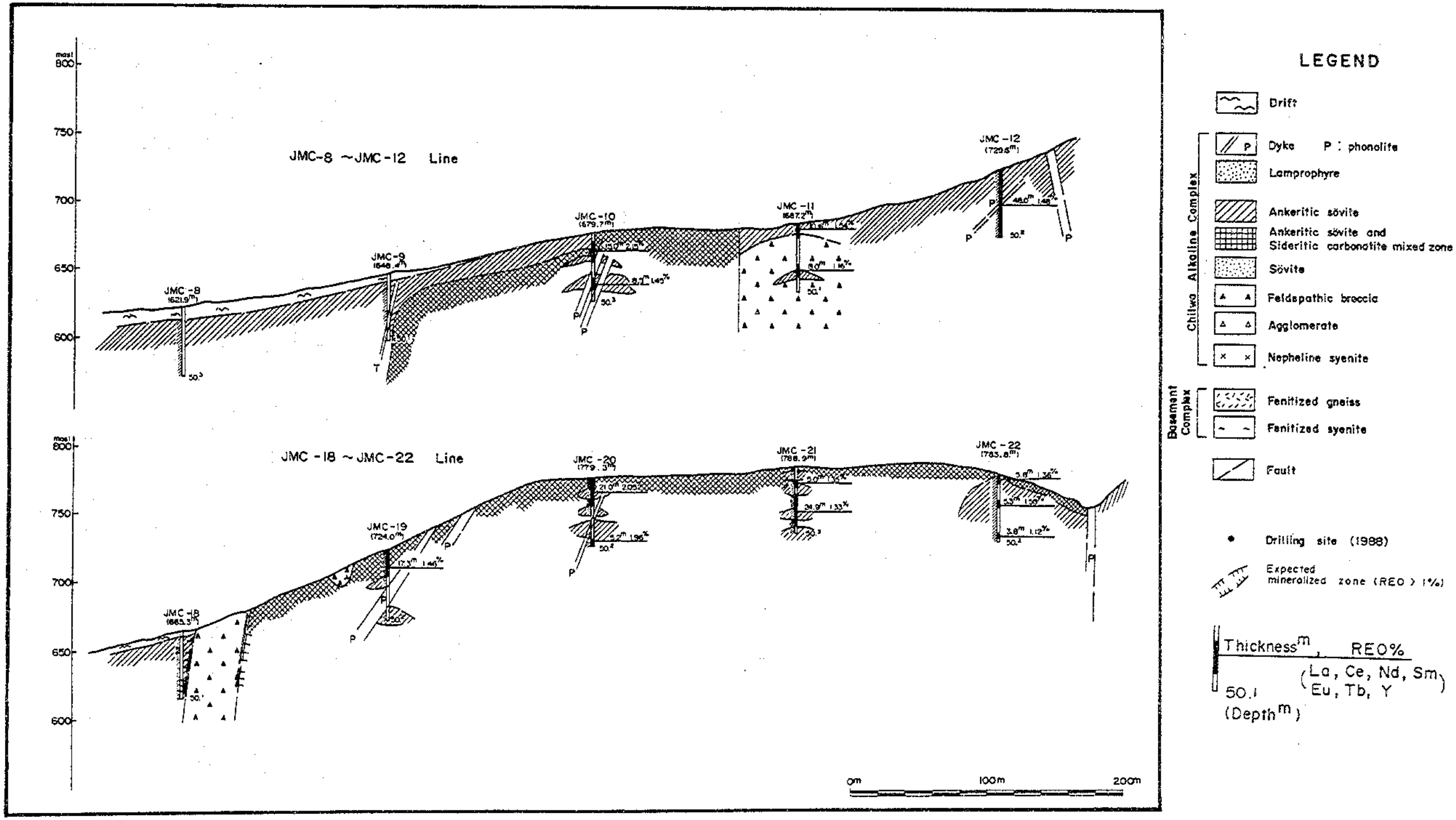


Fig.21 - 2 Geological section of drill holes, Chilwa Island

Tab.18 Obeservation of the Chilwa Island carbonatites

Sample No.	Field		Thin section		X-ray diffractometer
	Name	Description	Name	Description	Mineral
C3003	sövite	medium-grained white to brown calcite	sövite	calcite (0.05–0.7mm) with amount of barite, quartz and pyrite, mosaic texture	calcite ≫ dolomite = quartz = = barite
C1304	ankeritic sövite	fine-grained reddish brown carbonate	ankeritic sövite	carbonate (–0.15mm), porphyritic texture	ankerite > dolomite
C2208	ankeritic sövite	fine-grained white and reddish brown carbonate	ankeritic sövite	carbonate (0.2–1.0mm), porphyritic texture	ankerite = siderite ≫ quartz = pyrite
C2810	ankeritic sövite	pyrite bearing fine-grained white carbonate	ankeritic sövite	carbonate (0.1–1.25mm) with K-feldsper, quartz, pyrite, fluorite and barite, mosaic texture	ankerite ≫ K-feldspar > quartz > barite
C2904	ankeritic sövite	fine-grained gray carbonate	ankeritic sövite	carbonate (0.1–0.7mm) with quartz pyrite, magnetite, and goethite	ankerite ≫ strontianite > quartz
C2106	sideritic carbonatite	black to dark brown coase-grained carbonate	altered carbonatite	euhedral to subhedral magnetite and goethite (1.5 – 7mm) with quartz, carbonate and K-feldspar	calcite = goethite > calkinsite = Synchysite = K-feldspar
C2408	ankeritic sövite	fluorite bearing medium-grained carbonate	sideritic carbonatite	euhedral to subhedral siderite (0.2–1.75mm) with quartz, barite and fluorite	siderite > fluorite > quartz > kutnahorite = barite

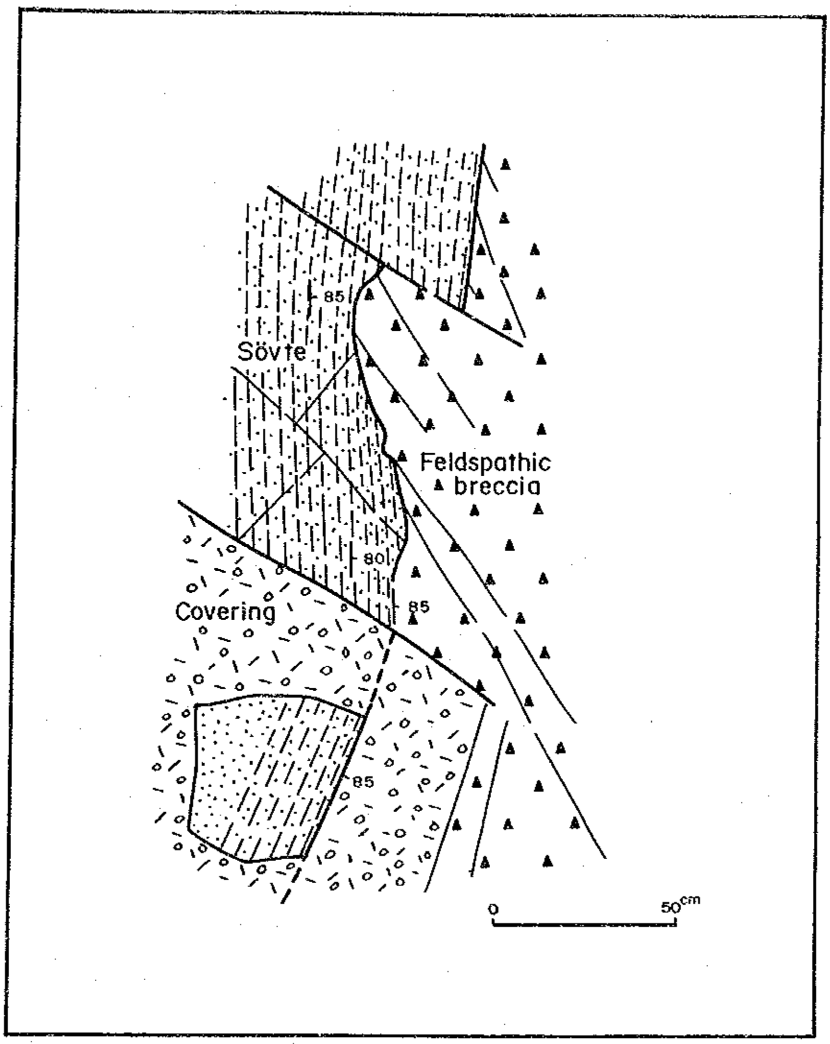


Fig.22 Sketch showing contact between banded sovite and feldspathic breccia, southern slop of Mulinde Hill

with sideritic one in the central part of Chilwa Island sector have the highest potential in this sector for REE mineralized zone. As for Nb resources, sovitic carbonatite around Northern Summit and JMC-3 is considered to have the highest potential.

Chapter 4 General discussion

4-1 Depth of formation of carbonatite bodies

Generally speaking, the variation in mode of field occurrence of the carbonatite is considered to depend on the depth of consolidation of magma (GSJ and DNPM, 1987). Thus it may be possible to estimate the depth of consolidation based upon the mode of occurrence (Garson, 1965 and 1966).

During the third phase survey, schematic cross sections for carbonatites bodies in Tundulu, Songwe, Kangankunde and Chilwa Island sectors were drafted in order to compare the depth of formation of the bodies in each sector.

The common characteristics of geology of carbonatites bodies in "Chilwa Alkaline Province" are as follows:

1) constituent rocks have concentric arrangement
2) the shape of the bodies on a plane figure is elliptical, showing ring structure
3) adjoining basement rocks have undergone intense fenitization
4) the bodies tend to consist of sovitic, ankeritic and sideritic carbonatite from rim inward
5) breccias are often associated
6) constituent rocks tend to dip steeply outward or inward

Judged from the characteristics shown above, it is inferred that the depth of formation of the bodies are effusive and shallow level or intermediate plutonic level, which are the first and the second shallowest among the 3-fold division by GSJ and DNPM (1987).

As the carbonatite body in Kangankunde sector contains carbonatized breccias and shows ovoidal ring structure, it is inferred to be formed in rather deeper level than those of other sectors (Fig. 23).

4-2 Isotopic ratios of Carbon and oxygen

Carbon and oxygen isotopic ratios are analyzed for carbonatites and apatite rocks in "Chilwa-Alkaline Province" in order to elucidate their petrogenesis.

CO_2 generated through the decomposition reaction of carbonates with phosphates were analyzed with a mass spectrometer.

The procedure is as follows:

1) weigh 30 to 40 mg of previously ground samples (minus 200 mesh)
2) phosphoric acid (100%) is added to decompose samples in vacuum and at 25°C for 1 to 7 days
3) collect CO_2 generated and remove mixed H_2O by the aid of ethyl alcohol as a freezing mixture
4) contents of $\delta^{13}C$ and $\delta^{18}O$ in CO_2 are analyzed with mass spectrometer (Finnigan Mat Delta-E) at the Central laboratory of Mitubishi Metal Corporation.

The working standard, used is fossil coral CK-13 (aragonite of $\delta^{13}C_{PDB}$=+0.54‰ and $\delta^{18}O_{PDB}$=-1.75‰). The contents of $\delta^{18}O$ are further corrected for the kinetic fractionation in the phosphoric acid reaction with different minerals.

The relationship between $\delta^{18}O_{PDB}$ and $\delta^{18}O_{SMOW}$ is as follows:

$$\delta^{18}O_{SMOW} = 1.03086\ \delta^{18}O_{PDB} + 30.86‰$$

Tab. 19 shows isotopic ratios of carbonates in Chilwa Island and Tundulu sectors.

Tab.19 Isotopic composition of the carbonatites

No	Sample No	Sector	Rock name	Mineral	$\delta^{13}C$ (PDB)	$\delta^{18}O$ (PDB)	$\delta^{18}O$ (SMOW)
1	8Y009	Chilwa Is	ankeritic sövite	ankerite	-4.5	-22.0	+ 8.2
2	8Y026	"	"	dolomite > calcite	-2.4	-20.1	+10.1
3	8Y038	"	sövite	calcite > dolomite	-3.8	-19.7	+10.6
4	8Y058	"	"	calcite > ankerite	-3.2	-18.2	+12.1
5	8Y068	"	sideritic carbonatite	fluorite > Fe	-6.6	-10.2	+20.3
6	8Y124	"	"	fluorite > Fe	-6.7	-12.2	+18.3
7	8Y153	Tundulu	apatite rock	apatite > quartz > calcite	-6.2	-24.7	+ 5.4
8	8Y154	"	"	"	-7.4	-21.5	+ 8.7
9	JMT-7	"	sideritic carbonatite	kutnahorite > calcite	-2.3	- 9.9	+20.7
10	JMT-22	"	ankeritic sövite	ankerite > siderite	-5.4	-23.3	+ 6.8
11	JMT-26	"	sideritic carbonatite	kutnahorite > calcite	-5.0	- 8.6	+22.0

Analyzed results are plotted on the figure in comparison with those of various rock types (Fig. 24).

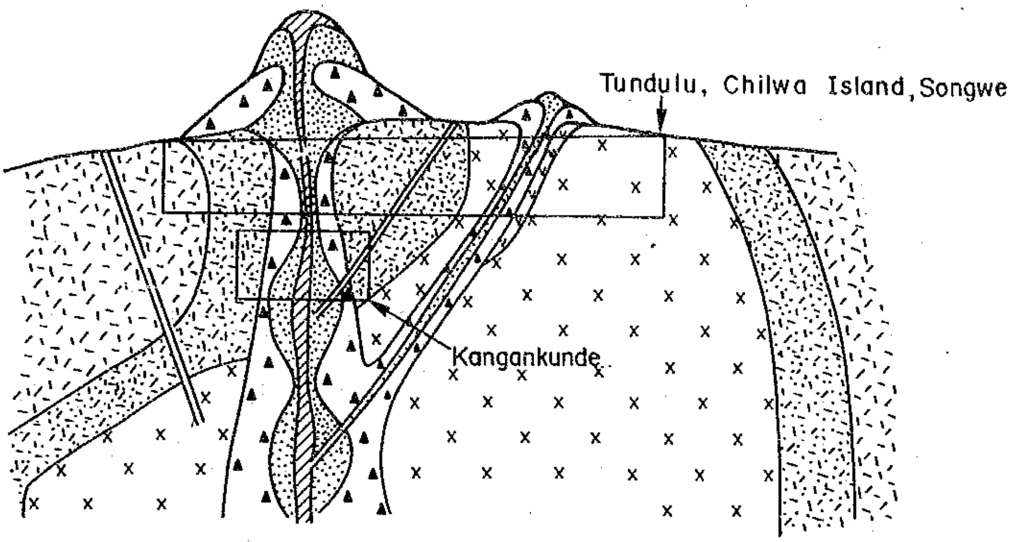
$\delta^{13}C$ in carbonatites from "Chilwa Alkaline Province" are distirubted in the range of -7.4‰ to -2.3‰ and $\delta^{18}O$ are in two ranges of +5.4‰ to 12.1‰ and +18.3‰ to 22.0‰. The values of $\delta^{13}C$ are similar to those from common carbonatites and diamond. While the values of $\delta^{18}O$ are plotted in the area of such igneous rocks as basalt and granite. Analyzed samples with higher $\delta^{18}O$ ranging from 18.3‰ to 22.0‰ are plotted in the are of sedimentary rocks, but it is inferred that these samples have undergone low-temperature hydrothermal alteration.

The relationship between $\delta^{13}C$ and $\delta^{18}O$ is shown in Fig. 25. The square labeled as Oka Box in the figure represents the isotopic ratios of carbonatites from Oka, Canada (Deines, 1970). The ratios of Mbeya carbonatites of Tanzania are also plotted after Suwa et al. (1969).

As shown in the figure, among the samples of apatite rock, sovitic and ankeritic carbonatites of "Chilwa Alkaline Province", two are plotted in the Oka Box and five out of it but around the Box. These seven samples are inferred to be of magmatic origin, because it has generally been assumed that the values of $\delta^{13}C$ and $\delta^{18}O$ of igneous rocks are low. The rest four of samples show higher $\delta^{18}O$ and low $\delta^{13}C$. Bulk chemical analysis for these rocks show that Fe-oxides content ranges from 13.55% and 47.38%. There is a large possibility that, in rocks showing high $\delta^{18}O$ and low $\delta^{13}C$, metal oxides hold a high concentration of $\delta^{18}O$. The enrichment in $\delta^{18}O$ is inferred to be related to the interaction of magmatic oxygen with that of the atmosphere and meteoric water.

4-3 Bulk chemical composition of carbonatites

In order to elucidate the chemical characteristics of carbonatites whose classification have been made based upon field observation, ten of sovitic one, six of ankeritic one, seven of sideritic one and two of apatite rock were analyzed (Tab. 20).



LEGEND

Upper Jurassic to Lower Cretaceous
- Dike
- Ankertic, sideritic carbonatite, apatite rock
- Sövite
- Agglomerate, feldspathic breccia
- Nepheline syenite
  - Carbonate silicate rock
  - Fenitized rock

Upper Precambrian To Lower Cambrian
- Basement complex

Fig.23 Schematic diagram of the carbonatite complex in the Chilwa Alkaline area

Fig. 26 is a triangular diagram of molar MgO, CaO and, FeO and MgO, CaO, SiO_2. Among the analyzed carbonatites, all of sovitic one and one of ankeritic (8Y005) are plotted in sovitic field. Two (JMT-7 and JMT-26) out of seven sideritic ones are plotted in ankeritic field. Samples of 8Y030 and 8Y110 are inferred to be sideritic ones mixed with ankeritic and sovitic, respectively.

4-4 REE contents in carbonatites

It has been found out that La and Ce are enriched in carbonatites. High contents of these elements are solely due to the occurrence of bastnaesite, synchysite and parisite in carbonatites.

Besides these elements, Nb, Sm, Eu and Tb have been analyzed for carbonatites in the survey area to summarize their abundance and distribution.

To research for a major host phase in the carbonatites, rare elements in such minerals as pyrochlore, bastnaesite, rutile and apatite were analyzed. Fig. 27 shows REE pattern for the representative rocks from each sector. It is seen from the figure that samples from Songwe sector are more enriched in medium REE than those from Tundulu, Kangankunde and Chilwa Island sectors as well as from Mountain Pass Mine. Eu and Tb contents of Songwe samples are higher as compared with those of Bayan Obo Mine.

Analyzed results using EPMA show that Th content in bastnaesite from Songwe and Tundulu sectors is 0.01 to 0.19 weight % and that in apatite from Chilwa Island it is 1.21 weight % (Tab. 21).

In Tab. 22 are presented a comparison of ore reserves and grade of carbonatites ore deposits from Songwe and Tundulu sectors with those in the world.

As the estimation of ore reserves is based on the assumption that mineralized zone extends 50m below the surface, it is impossible to compare the ore reserves of REO and P_2O_5 with those of other mines.

REO contents in Songwe and Tundulu sectors, the values of which are 1.7% and 2.1% respectively, are rather lower as compared with the value of 2.0% of Bayan Obo Mine, but the content of medium REE in Songwe sector is 1.5 to 2 times higher than that of Bayan Obo Mine.

Recently, the total amount of consumption of REE has steadily decreased after the peak of 1983, but that of REE with high purity tends to

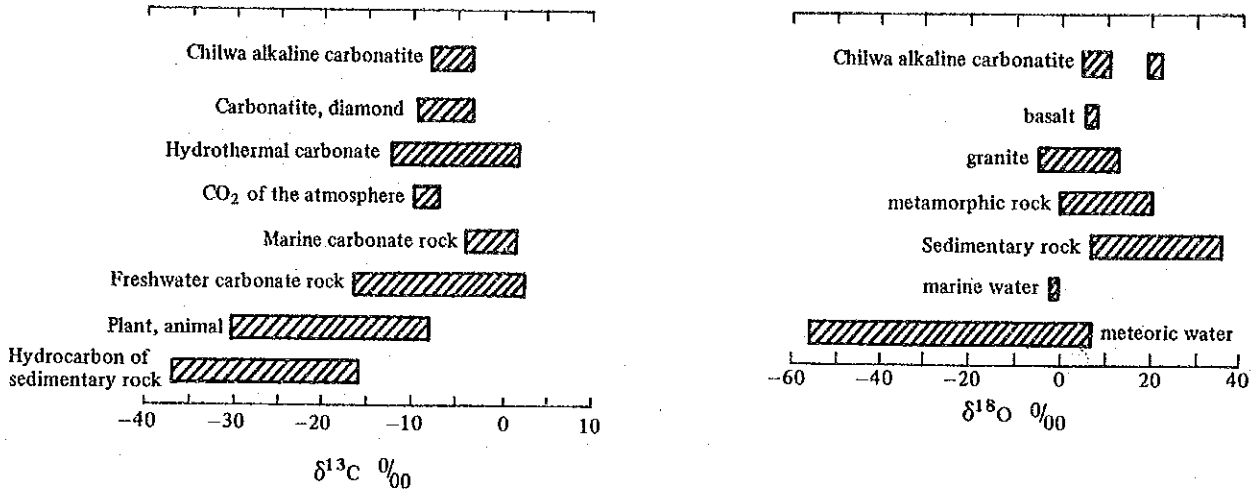


Fig.24 The carbon and oxygen isotopic ratios of the materials

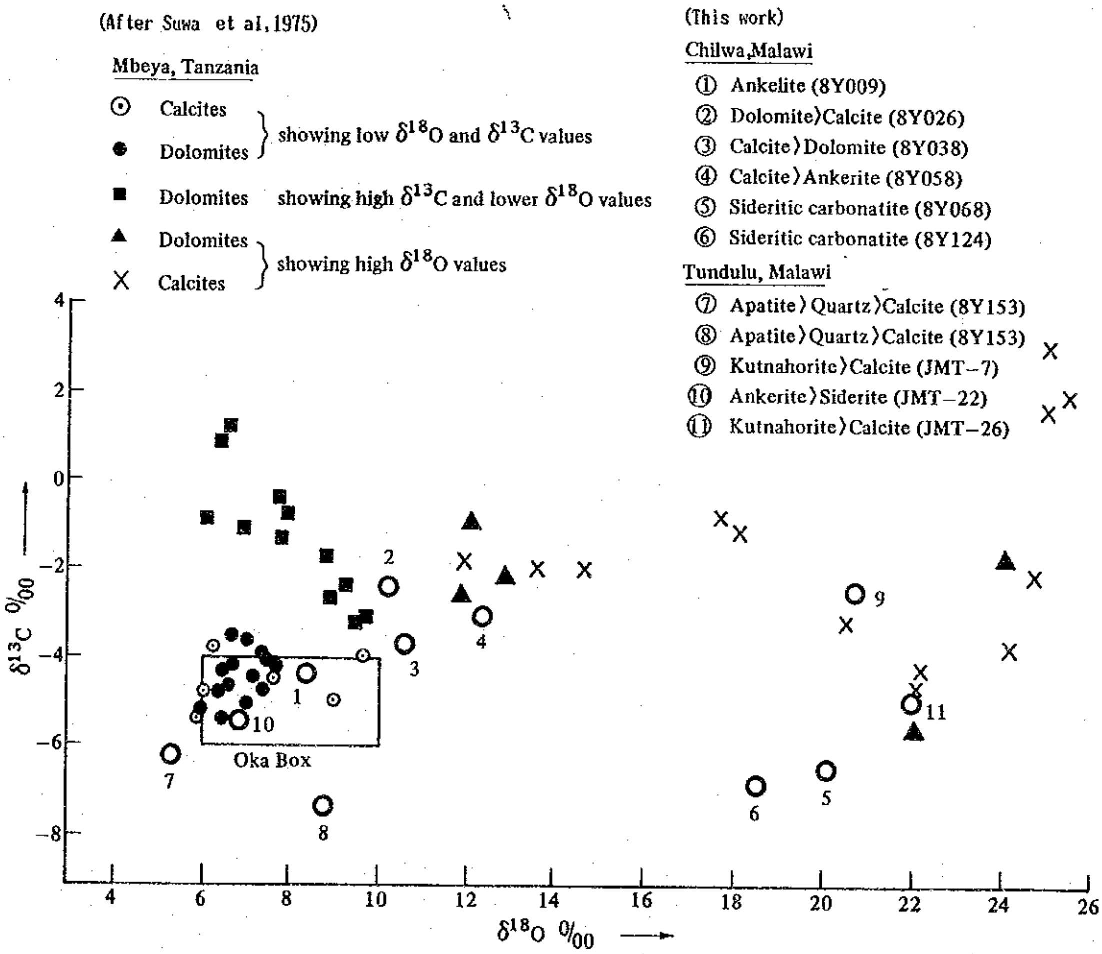


Fig.25 The oxygen and carbon isotopic ratios of carbonates in Chilwa Alkaline area carbonatite, southern Malawi and Mbeya carbonatite, southern Tanzania

Tab.20 Chemical composition of the carbonatites

Rock	2	2	3	2	3	1	1	2	1	1	1	1	3	3	2	3	1	1	1	1	4	4	3	2	3
Sample	8Y005	8Y009	8Y018	8Y026	8Y030	8Y038	8Y041	8Y046	8Y047	8Y052	8Y055	8Y058	8Y068	8Y103	8Y110	8Y124	8Y128	8Y147	8Y148	8Y150	8Y153	8Y154	JMT07	JMT22	JMT26
SiO2	2.63	13.08	0.16	1.05	0.99	1.56	1.99	2.57	1.37	2.39	2.38	4.59	15.46	1.96	24.12	0.40	2.66	13.99	16.16	3.95	25.94	30.13	1.16	10.60	2.54
TiO2	<0.01	0.01	<0.01	0.02	0.03	<0.01	0.01	0.04	0.02	0.02	0.02	0.19	<0.01	0.01	0.31	0.03	<0.01	0.66	0.46	0.02	0.01	<0.01	0.05	0.06	<0.01
Al2O3	1.31	0.41	0.12	0.25	0.09	0.23	0.52	0.47	0.05	0.19	0.20	0.12	5.27	0.17	6.56	1.58	0.27	0.53	2.82	0.33	0.33	0.21	0.21	0.09	0.03
Fe2O3	11.52	0.01	49.30	0.06	29.53	4.20	2.25	7.57	0.37	5.41	0.83	2.44	47.38	32.34	19.12	48.64	2.04	14.29	7.11	1.50	0.56	1.62	14.66	5.48	13.55
FeO	<0.01	7.76	<0.01	4.92	<0.01	0.21	0.49	0.64	2.39	<0.01	2.76	1.60	<0.01	<0.01	<0.01	<0.01	0.59	1.21	0.80	0.44	0.19	0.13	<0.01	8.97	<0.01
MnO	5.38	2.88	8.03	1.28	6.76	0.84	0.28	2.35	0.09	0.79	0.52	0.19	5.59	10.97	2.51	8.64	0.35	0.30	0.71	0.30	0.07	0.17	3.45	2.69	3.70
MgO	0.16	12.49	0.41	18.29	4.94	0.37	0.10	17.19	0.89	0.17	0.92	0.27	0.38	0.54	0.40	0.34	0.19	0.16	1.73	0.18	0.02	0.02	9.50	7.81	6.83
CaO	37.69	21.15	22.64	25.10	23.21	45.65	47.61	23.16	47.71	46.30	43.82	42.81	8.57	21.40	20.32	25.99	48.26	38.05	32.57	46.56	39.51	28.75	26.29	17.83	22.30
SrO	0.83	0.50	0.09	0.34	0.15	0.86	1.09	0.47	0.63	0.28	0.96	0.98	0.13	0.21	0.28	0.11	0.66	0.66	0.18	0.91	0.71	0.63	4.47	6.74	8.12
BaO	1.50	0.40	1.45	0.98	0.50	0.26	0.14	0.29	0.18	0.18	0.56	0.03	1.62	0.99	0.89	1.39	0.21	0.08	0.74	0.57	0.04	0.62	1.16	1.97	2.85
K2O	0.04	0.04	0.02	0.08	0.01	0.07	0.11	0.08	0.01	0.04	0.10	0.02	3.27	0.04	2.46	0.25	0.15	0.07	2.22	0.21	0.05	0.01	0.15	0.02	0.01
Na2O	0.04	0.02	<0.01	0.02	<0.01	0.08	0.03	0.05	0.07	0.02	0.07	0.08	0.02	<0.01	0.03	<0.01	0.04	0.43	0.07	0.04	0.54	0.46	0.02	0.08	0.02
P2O5	14.07	0.44	0.04	0.03	0.04	1.34	3.31	0.24	0.03	0.39	0.62	1.41	0.27	0.16	0.45	0.09	1.21	4.29	0.08	0.80	29.71	26.14	0.02	<0.01	<0.01
Nb2O5	0.01	0.20	0.00	0.08	0.00	0.04	0.01	0.05	0.16	0.08	0.11	1.31	0.00	0.01	0.04	0.01	0.01	0.18	0.07	0.21	0.00	0.00	0.02	0.07	<0.01
REO	1.63	0.61	1.43	0.59	0.87	0.23	0.12	0.87	0.24	0.15	0.32	0.12	1.13	2.93	0.52	0.34	0.13	0.12	0.18	0.13	0.49	0.36	2.38	3.87	4.51
LOI	22.35	40.47	16.07	46.73	32.71	43.13	41.18	43.93	45.71	43.24	44.98	43.48	10.82	27.96	21.60	11.83	42.47	24.18	33.89	43.53	1.03	10.78	37.26	33.93	36.90
CO2	9.65	34.58	8.24	38.74	22.17	33.43	31.41	35.13	36.61	35.19	37.18	33.42	0.60	17.47	12.04	3.52	32.59	17.31	26.73	35.12	0.99	1.63	26.14	27.86	26.81
S	0.10	0.02	0.03	0.03	0.01	0.03	<0.01	0.01	0.06	<0.01	0.54	<0.01	0.23	0.03	0.07	0.12	<0.01	<0.01	0.30	0.12	<0.01	0.02	0.21	1.85	0.42
ToTal	99.17	100.47	99.78	99.82	99.84	99.07	99.24	99.97	99.93	99.65	99.17	99.64	99.92	99.70	99.62	99.64	99.34	99.20	99.78	99.68	99.19	100.03	100.80	100.22	101.38

Mole %

Sample	8Y005	8Y009	8Y018	8Y026	8Y030	8Y038	8Y041	8Y046	8Y047	8Y052	8Y055	8Y058	8Y068	8Y103	8Y110	8Y124	8Y128	8Y147	8Y148	8Y150	8Y153	8Y154	JMT07	JMT22	JMT26
SiO2	3.58	11.73	0.26	0.92	1.23	1.55	1.99	2.40	1.28	2.31	2.23	4.56	28.08	2.73	30.61	0.65	2.61	15.75	16.39	3.76	30.94	39.47	1.27	10.64	2.88
TiO2	0.01	0.01	0.01	0.01	0.03	0.00	0.01	0.03	0.01	0.01	0.01	0.14	0.01	0.01	0.30	0.04	0.00	0.56	0.35	0.01	0.00	0.00	0.04	0.05	0.00
Al2O3	1.05	0.22	0.11	0.13	0.07	0.13	0.31	0.26	0.03	0.11	0.11	0.07	5.64	0.14	4.91	1.52	0.16	0.35	1.69	0.19	0.23	0.16	0.14	0.05	0.02
Fe2O3	5.91	0.00	29.72	0.02	13.76	1.57	0.85	2.66	0.13	1.96	0.29	0.91	32.38	16.95	9.13	29.92	0.75	6.05	2.71	0.54	0.25	0.80	6.04	2.07	5.79
FeO	0.01	5.82	0.01	3.60	0.01	0.17	0.41	0.50	1.87	0.00	2.16	1.33	0.01	0.01	0.01	0.01	0.57	1.14	0.68	0.35	0.19	0.14	0.00	7.53	0.00
MnO	6.21	2.19	10.90	0.95	7.09	0.71	0.24	1.86	0.07	0.65	0.41	0.16	8.60	12.94	2.70	11.96	0.29	0.29	0.61	0.24	0.07	0.19	3.20	2.29	3.56
MgO	0.33	16.70	0.98	23.87	9.12	0.55	0.15	23.89	1.24	0.24	1.28	0.40	1.03	1.12	0.76	0.83	0.28	0.27	2.62	0.26	0.04	0.04	15.50	11.69	11.56
CaO	55.04	20.32	38.86	23.55	30.80	48.61	50.99	23.13	47.90	47.88	43.94	45.55	16.68	31.94	27.63	45.52	50.66	45.90	35.40	47.52	50.49	40.35	30.84	19.19	27.12
SrO	0.65	0.26	0.09	0.17	0.10	0.50	0.63	0.26	0.34	0.16	0.52	0.57	0.13	0.17	0.21	0.10	0.37	0.43	0.10	0.50	0.49	0.48	2.84	3.92	5.34
BaO	0.80	0.14	0.91	0.34	0.24	0.10	0.05	0.11	0.07	0.07	0.21	0.01	1.15	0.54	0.44	0.89	0.08	0.04	0.29	0.21	0.02	0.32	0.50	0.78	1.27
K2O	0.03	0.02	0.02	0.04	0.01	0.04	0.07	0.05	0.01	0.02	0.06	0.01	3.79	0.04	1.99	0.26	0.09	0.05	1.44	0.13	0.04	0.01	0.10	0.01	0.01
Na2O	0.05	0.02	0.01	0.02	0.01	0.08	0.03	0.05	0.06	0.02	0.06	0.08	0.04	0.01	0.04	0.01	0.04	0.47	0.07	0.04	0.62	0.58	0.02	0.08	0.02
P2O5	8.12	0.17	0.03	0.01	0.02	0.56	1.40	0.09	0.01	0.16	0.25	0.59	0.21	0.09	0.24	0.06	0.50	2.04	0.03	0.32	15.00	14.49	0.01	0.00	0.00
Nb2O5	0.00	0.04	0.00	0.02	0.00	0.01	0.00	0.01	0.03	0.02	0.02	0.29	0.00	0.00	0.01	0.00	0.00	0.05	0.02	0.05	0.00	0.00	0.01	0.02	0.00
CO2	17.96	42.34	18.02	46.30	37.49	45.36	42.87	44.71	46.83	46.37	47.50	45.31	1.49	33.23	20.86	7.86	43.59	26.61	37.02	45.67	1.61	2.92	39.07	38.20	41.54
S	0.26	0.03	0.09	0.05	0.02	0.06	0.01	0.02	0.11	0.01	0.95	0.01	0.78	0.08	0.17	0.37	0.01	0.01	0.57	0.21	0.01	0.05	0.43	3.48	0.89

Mole ratio (%)																									
MgO	0.56	34.26	2.44	49.38	22.16	1.08	0.28	48.34	2.46	0.48	2.70	0.79	2.25	3.13	1.29	1.77	0.52	0.44	4.82	0.50	0.05	0.05	32.56	28.16	27.82
CaO	93.37	41.68	96.91	48.72	74.85	95.86	95.97	46.80	95.00	94.94	92.60	90.18	36.43	89.24	46.83	96.85	94.60	74.13	65.06	92.20	61.97	50.53	64.78	46.22	65.26
SiO2	6.07	24.06	0.65	1.90	2.99	3.06	3.75	4.86	2.54	4.58	4.70	9.03	61.32	7.63	51.88	1.38	4.87	25.44	30.12	7.30	37.98	49.42	2.67	25.63	6.93

Mole ratio (%)																									
MgO	0.54	38.98	1.41	46.77	16.99	1.08	0.29	47.61	2.42	0.48	2.69	0.83	2.06	2.24	2.03	1.09	0.54	0.51	6.33	0.53	0.08	0.10	29.59	28.88	26.00
CaO	89.80	47.43	55.86	46.14	57.37	95.50	97.31	46.09	93.66	95.61	92.18	94.52	33.29	63.85	73.62	59.67	96.94	86.02	85.49	97.64	99.06	97.63	58.88	47.41	60.98
FeO	9.66	13.59	42.73	7.09	25.65	3.42	2.40	6.30	3.91	3.91	5.14	4.65	64.65	33.91	24.35	39.24	2.53	13.47	8.19	1.83	0.86	2.27	11.53	23.72	13.02

Rock	Field name
1	Sövite
2	Ankeritic sövite
3	Sideritic carbonatite
4	Apatite rock

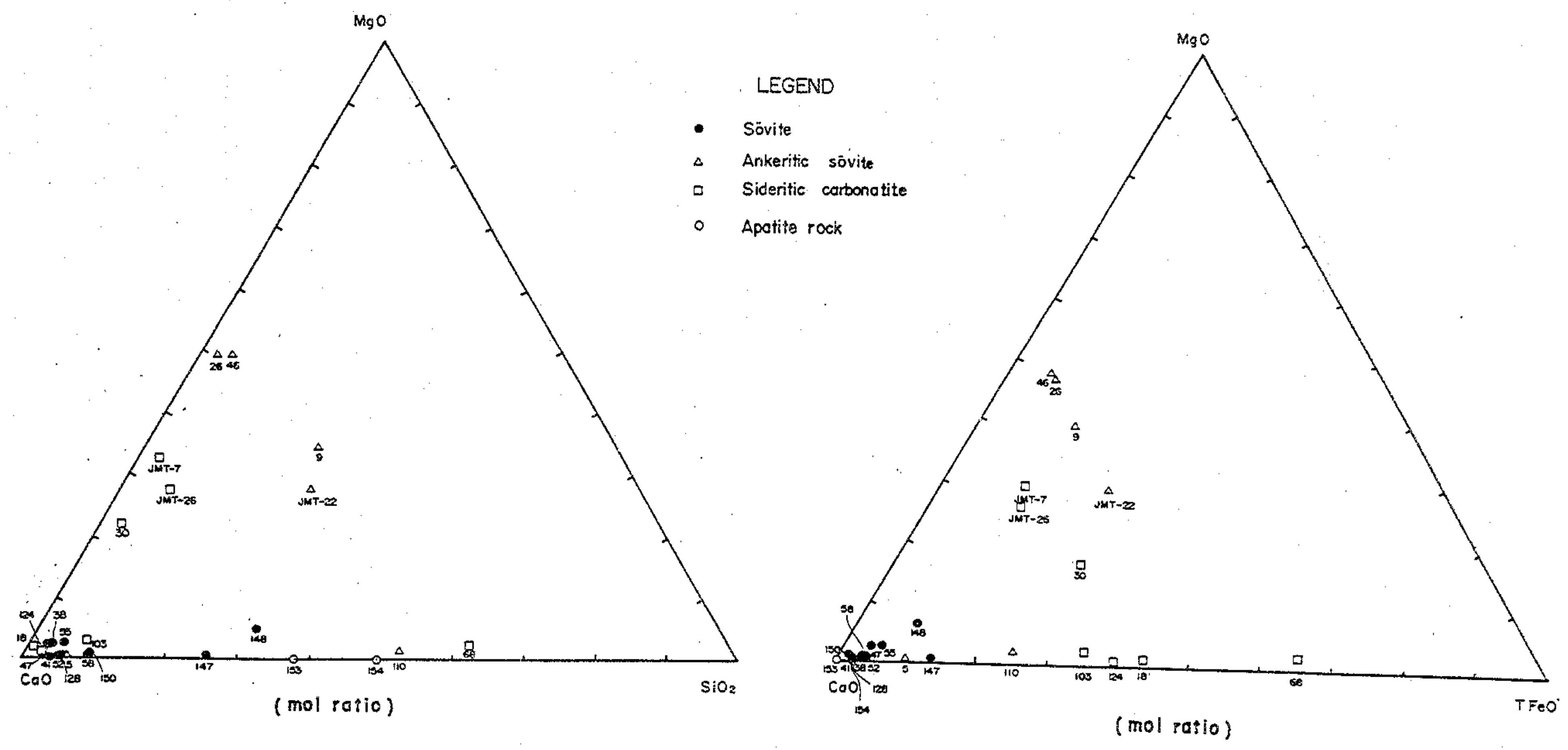


Fig.26 Ternary diagrams of the carbonatites

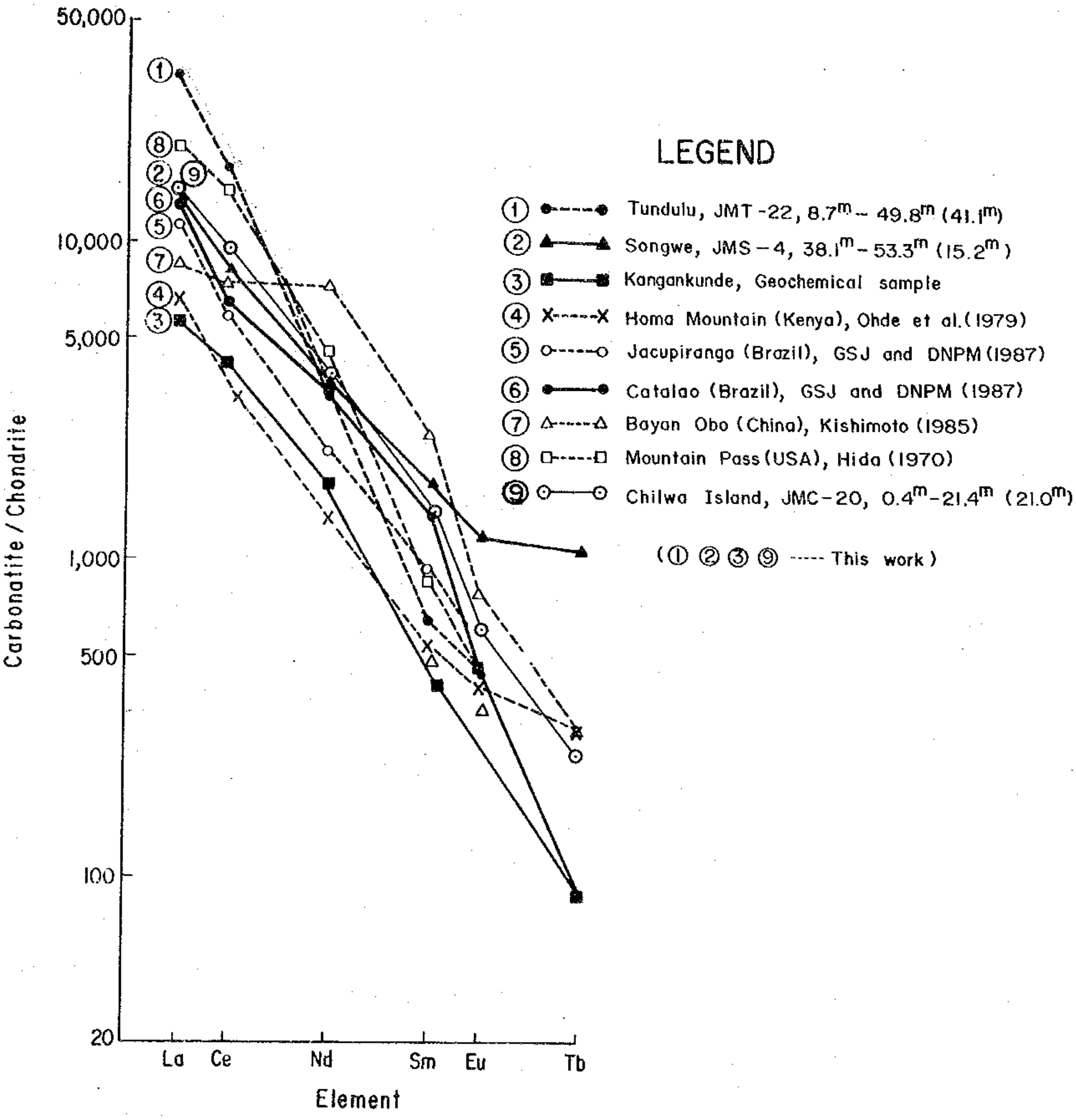


Fig. 27 Chondrite normalized rare earth concentration

Tab.21 Result of quantative EPMA analysis

No.	Sample No.	Sector	Locality	Rock name	Mineral	Element (wt %)											
						La	Ce	Sm	Gd	Dy	Nb	Y	Na	Ca	Ti	Th	Zr
1	C1306	Chilwa Island	JMC-13 30.2m	Apatite sövite	Rutil	0	9.68	0	0	0	4.43	0	0.14	1.19	69.6	0	0.29
2	C1306	"	"	"	Apatite	7.12	13.7	0	0.29	0	0	2.44	0.12	0.83	0	1.21	1.58
3	C3211	"	-32 47.4m	Sövite	Pyrochlore	0	2.76	0	0	0	47.4	2.50	1.06	14.0	1.70	0	4.13
4	S1604	Songwe	JMS- 4 14.0m	Iron oxide ore	Bastnaesite (?)	38.5	29.3	5.39	0.58	0	0.16	0	0.21	9.01	0	0.01	0
5	T2501	Tundulu	JMT-15 3.2m	Apatite rock	Pyrochlore	0	0.53	2.76	0	1.62	18.7	1.28	4.07	6.32	1.21	0	2.19
6	T2501	"	"	"	Bastnaesite	9.62	14.1	2.58	0.69	0	1.21	0	0.19	7.66	0	0	0
7	T2607	"	MJT-26 28.9m	Apatite rock	Pyrochlore	0	0.16	0.59	0	0.32	19.1	0.82	0.61	6.22	0.90	0	1.44
8	T2607	"	"	"	Bastnaesite	15.0	17.1	4.67	0.20	0	0	0	0	5.90	0	0.19	0
9	8Y058	Chilwa Island	Surface	Sövite	Pyrochlore	0	1.33	3.90	0	0	37.8	1.82	1.03	11.0	1.68	0	3.26
10	8Y058	"	"	"	Pyrochlore	0	1.69	0	0.84	0	33.1	3.01	1.06	12.8	1.28	0	3.70

increase. Light REE are in overstock while medium to heavy REE are in deficiency of supply.

The grade of phosphorus (P_2O_5) in Tundulu sector is estimated to be as high as 17.0%. This ore grade is higher than Araxa (P_2O_5 15%) or Sukulu (P_2O_5 13%). This phosphorus deposit is possible to be exploited for the phosphatic fertilizer. It is inferred that one way of using the phosphorus resources could be for the production of fused magnesium phosphate (50,000 tons/year, approximately 10,000 tons in P_2O_5 equivalent) by the aid of domestic resources of ultrabasic rocks or dolomitic rocks as well as electric power.

Tab.22 REO & P_2O_5 resources related carbonatite/alkaline complex

Name of complex	Type of carbonatite	REO			P_2O_5		
		(Mil.t) Reserves	(%) Ore grade	(Th.t) Metal	(Mil.t) Reserves	(%) Ore grade	(Th.t) P_2O_5
Songwe, (Malawi) (This work)	sövite, ankeritic	1.4	1.7	23.8			
Tundulu, (Malawi) (This work)	ankeritic, sideritic, apatite	0.6	2.1	12.6	0.5	17.0	85.0
Araxa, (Brazil)	beforsite, sövite				460	15.01	69,046
Tapira (Brazil)	sövite				921	8.32	76,627
Catalao (Brazil)	beforsite,	2	12.20	244	306	7.96	24,358
Jacupiranga (Brazil)	sövite, beforsite				89	6.15	5,474
Ipanema (Brazil)	Sövite				117	6.73	7,874
Oka (Canada)	sövite	122	0.2	244			
Sukulu (Uganda)	carbonatite				200	13.0	26,000
Siilinjarvi (Finland)	sövite				465	4.0	18,600
Mountain Pass (USA)	carbonatite	100	5-10				
Rayan Obo (China)	carbonatite	(REO) 35	1.9-13.5				

(after GSJ and DNPM, 1987)

Part III Conclusion and recommendation

Chapter 1 Conclusion

During the third phase, drilling survey have been done in Songwe and Tundulu sectors, geological, geochemical and drilling surveys in Chilwa Island sector.

The following are the results of the surveys.

(1) Songwe sector

1. Carbonatites in this sector are classified into sovitic, ankeritic and breccias.

2. Useful minerals enriched in REE, Nb, Sr and P are bastnaesite, synchysite, parisite, strontianite, monazite, pyrochlore and apatite.

3. Carbonatites are developed showing an elliptical structure centering Songwe Hill, lining up in two files of N-S trend. Dip is as steep as 70° to vertical.

4. A REE-mineralized zone rich in medium REE is recognized on the northern slope of Songwe Hill (lower than 850m asl).

5. Based upon the results of drilling, six REE-mineralized zones, which are more than 10m thick in core showing the grade of REO more than 1.0%, are discriminated. The ore reserve estimation has been made based upon the assumption that mineralized zone extends 50m beneath the surface. The results are that the ore reserves are about 1.4 million tons and the grade of REO is 1.7%.

6. REE content of the mineralized zones indicate that the averaged values of such medium REE as Eu and Tb are 1.4 to 2 times higher than those of ores from Bayan Obo Mine (China).

From the results of the surveys, it is inferred that mineralized zones with comparatively high contents of medium REE are recognized on the northern slope of Songwe Hill.

As the underground extent of ore deposits has not yet been defined, it is impossible to compare the ore reserves with those of other mines.

As compared with the grade of ores from Bayan Obo Mine, REO content is rather lower, but the content of medium REE is higher.

It is inferred that, of course depending on the market condition of REE, this sector is possible to be exploited.

(2) Tundulu sector

1. Carbonatites in this sector are classified into sovitic, ankeritic, sideritic, apatite rock and breccias.

2. Useful minerals enriched in REE, Nb, Sr and P are bastnaesite, synchysite, strontianite, pyrochlore and apatite.

3. Carbonatites are developed showing superposed double ring structure centering Nathace Hill. The outer ring is composed of sovitic, and the inner one of ankeritic, sideritic and apatite rock.

4. REE- or phosphorus-mineralized zones in carbonatite or apatite rock are recognized in the inner ring at Nathace Hill.

5. Based upon the results of drilling, three REE-mineralized zones, which are more than 10m thick in core showing the grade of REO more than 1.0%, are discriminated. One phosphorus-mineralized zone is recognized, which is more than 10m thick in core showing more than 2.2% P content.

6. The ore reserve estimation has been made based upon the assumption that mineralized zone extends 50m beneath the surface. The results are that REE-ore reserve is about 0.6 million tons and the grade of REO is 1.7%. Phosphorus-ore reserve is about half million tons and the grade of phosphorus (P_2O_5) is estimated to be 17.0%.

From the results of the surveys, it is inferred that mineralized zones of carbonatites with comparatively high contents in REE and phosphorus are recognized on the eastern and southern slope of Nathace Hill. Carbonatites associating apatite rock is highly enriched in phosphorus.

Because REE minerals are closely associated with phosphorus minerals and the grades of REO as well as medium REE are not so high as compared with those of other mines, it is not advantageous to make exploitation now.

The grade of phosphorus (P_2O_5) is estimated to be as high as 17.0%. It is inferred that the phosphorus resources can be useful for the production of fused magnesium phosphate by the aid of domestic resources of ultrabasic rocks or dolomitic rocks as well as electric power.

(3) Chilwa Island sector

Geological survey

Carbonatites are developed on and around the top of the Island from Mbirikwi, Michulu and Chinyobi Hills through Northern and Southern summits to Mulinde Hill.

The carbonatite body occurs in a ring structure of 2km diameter, showing distinct zonal arrangement, i.e., from outside to inside, are arranged sovitic carbonatite, ankeritic carbonatite and its mixed rocks with sideritic carbonatite.

Useful minerals enriched in REE, Nb, Sr and P are pyrochlore, synchysite, strontianite, apatite and fluorite.

Geochemical survey

It is concluded that the central part occupied by ankeritic carbonatite and its mixed zone with sideritic carbonatite have higher anomaly for REE and Sr, while outer part occupied by sovitic and ankeritic carbonatites have higher anomaly for Nb and P, respectively.

Drilling survey

In Chilwa Island sector, REE-mineralized zones having more than 1.0% of REO are recognized at JMC-3, 7, 10, 11, 12, 14, 19, 20, 21, 22, 25, 26, 28 and 29. Among them, at JMC-3, 10, 11, 12, 19, 20, 21, 26 and 29, the thickness of mineralized zones are over ten meters.

These mineralized zones are usually found in ankeritic and its mixed zone with sideritic carbonatites.

The largest-scaled mineralized zone is recognized in ankeritic carbonatite at JMC-12, which is 48.0m thick in core having the REO grade of 1.48%.

From the results of the surveys, it is inferred that the central and the adjoining ankeritic carbonatite or its mixed zone with sideritic carbonatite have the highest potential for REE resources especially for medium REE. While, the outer part occupied by sovitic carbonatite have the highest potential for P- and Sr- resources.

Chapter 2 Recommendation for the future

Integrated interpretation of the results of the third phase survey and the previous works recommends the follows to evaluate potential of REE and phosphorous resources to estimate ore reserve and grade as well as expected profits in Songwe, Tundulu and Chilwa Island sectors.

(1) Songwe Sector

A REE-mineralized zone rich in medium REE has been recognized as deep as 50m beneath the surface.

Up to now, it is rather disadvantageous to exploit the sector as REE resources, but taking the higher content of medium REE into consideration detailed survey shall be carried out to define extent, reserve and grade of ore deposits in hitherto detected mineralized zones aiming at increasing the reserves for the future.

Based upon the results, the effect of exploitation shall be discussed on the view point of economy.

(2) Tundulu sector

REE- or phosphorus-mineralized zones in carbonatite or apatite rock are recognized at Nathace Hill.

The estimated grade of Phosphorus (17% in P_2O_5 equivalent) is high enough to be exploited for the production of fused magnesium phosphate.

Further detailed drilling survey shall be carried out to define extent, reserve and grade of ore deposits in hitherto detected mineralized zones with geochemical anomaly aiming at increasing the reserves.

Based upon the results, the effect of exploitation shall be discussed on the view point of economy.

(3) Chilwa Island sector

Through the third phase survey, it is recognized that ankeritic carbonatite or its mixed zone with sideritic carbonatite have the highest potential for medium REE-economic resources.

Detailed geological and drilling surveys in the same way as Songwe sector shall be carried out to define extent and grade of ore deposits in the detected mineralized zones for the future.

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Appendices

Appendix 1

Assay results (Geochemical samples)

Abbrevation

Area

C : Chilwa Isiand

Rock

10 : carbonatite

20 : others (Alkaline rock)

30 : others

OCC

1 : massive 2 : sheet

3 : dyke 4 : agglomerate

5 : breccia

REO

$La_2O_3+CeO_2+Nd_2O_3+Sm_2O_3$
$+Eu_2O_3+Tb_2O_3+Y_2O_3$

Units

ppm

Sample	Rock	Occ	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
8Y001	12	1	603	1177	422	48.00	16.20	.05	1440.0	1876	150	96.0	2909.72
8Y002	2	3	200	369	123	38.50	13.40	7.70	454.0	501	103	2610.0	1031.00
8Y003	12	1	512	907	297	14.50	11.10	6.20	878.0	9632	86	4484.0	2206.70
8Y004	12	1	4187	6130	1731	304.20	84.10	21.10	343.0	4506	542	4997.0	15620.22
8Y005	14	0	4205	7050	1743	209.80	34.20	.05	68.0	7003	331	61403.0	16325.60
8Y006	14	0	17299	26446	6021	685.70	91.40	15.30	79.0	4291	354	7379.0	61156.34
8Y007	13	1	6423	10529	2548	326.90	53.40	13.30	252.0	2788	280	574.0	24246.71
8Y008	13	1	11318	17613	4453	598.10	93.50	8.90	184.0	3926	398	3154.0	41414.75
8Y009	13	1	1372	2624	929	117.80	24.30	1.80	1365.0	4218	45	1927.0	6138.85
8Y010	13	1	497	994	398	72.50	21.20	.05	95.0	8979	77	5517.0	2474.18
8Y011	13	1	1415	2466	1002	233.20	67.00	5.30	365.0	5005	140	3645.0	6388.37
8Y012	13	1	1049	2085	875	166.70	43.10	20.30	.5	2474	71	1607.0	5167.92
8Y013	12	1	1109	2371	1177	344.80	110.30	19.20	.5	1922	276	506.0	6485.14
8Y014	13	1	461	998	1003	454.60	90.80	34.90	121.0	3343	245	1850.0	3919.60
8Y015	12	1	467	946	391	35.40	18.70	14.20	1009.0	9373	154	6661.0	2440.03
8Y016	14	1	1085	2172	701	133.00	28.20	.05	200.0	731	169	180.0	5158.91
8Y017	14	1	2240	4506	1798	335.30	82.30	15.70	96.0	9206	364	6818.0	11221.96
8Y018	14	1	2725	6385	2202	287.30	49.10	16.80	.5	798	237	167.0	14315.19
8Y019	14	1	4696	6948	1642	179.50	27.10	62.00	.5	13556	298	1073.0	16644.55
8Y020	14	1	10533	21450	8031	1158.00	206.00	19.50	.5	3537	947	1247.0	50866.92
8Y021	13	1	3905	6136	1793	291.60	62.90	15.70	38.0	7473	246	2616.0	14947.80
8Y022	13	1	5541	8248	2481	404.80	77.50	.05	.5	3325	327	498.0	20495.64
8Y023	13	1	2441	4749	1400	201.70	35.20	37.90	.5	8408	132	6130.0	10813.46
8Y024	13	1	5015	7938	2345	434.70	93.20	.05	34.0	2159	470	1157.0	19573.86
8Y025	13	1	1490	3117	1458	219.70	51.10	1.80	292.0	4091	139	2087.0	7768.10
8Y026	13	1	1115	2423	1105	158.50	35.20	.05	561.0	2871	80	139.0	5898.05
8Y027	13	1	1519	4935	3766	589.00	118.70	28.00	.5	2519	269	674.0	13427.68
8Y028	13	1	3211	5180	1717	275.10	58.10	.05	162.0	5292	158	973.0	12716.68
8Y029	14	1	4322	8496	2813	318.90	51.90	27.60	216.0	1258	522	1782.0	19907.48
8Y030	14	1	1842	3732	1152	153.90	31.50	22.40	.5	1232	309	180.0	8720.01
8Y031	14	1	2088	2998	457	90.80	16.60	20.60	.5	1439	114	3980.0	6956.67
8Y032	14	1	1577	3487	1068	168.90	25.90	.05	37.0	2960	188	5980.0	7841.88
8Y033	2	3	753	1400	438	79.80	17.50	.05	307.0	2363	125	8753.0	3384.82
8Y034	12	1	491	889	316	41.70	19.40	3.50	273.0	12028	164	6047.0	2319.24
8Y035	12	1	257	518	204	23.00	14.60	7.60	1311.0	3950	128	203.0	1390.32
8Y036	12	1	1363	2057	808	186.10	58.40	.05	1518.0	1930	294	2187.0	5723.86
8Y037	12	1	1198	2447	1122	169.80	46.60	25.70	506.0	1477	224	3135.0	6283.41
8Y038	12	1	424	876	364	29.00	17.60	5.00	285.0	7301	152	5835.0	2250.32
8Y039	12	1	538	1021	425	51.60	28.60	.10	1144.0	2938	268	736.0	2813.86
8Y040	12	1	649	1474	756	118.10	33.60	4.00	329.0	5044	154	3494.0	3828.93
8Y041	12	1	185	419	229	17.30	10.20	4.60	77.0	9206	94	14458.0	1155.11
8Y042	2	1	96	160	63	19.20	2.30	.05	39.0	831	46	1741.0	465.96
8Y043	3	1	51	79	31	10.20	.05	.05	15.0	726	36	1004.0	250.65
8Y044	3	1	72	123	47	8.40	2.30	.05	70.0	1663	28	950.0	338.33
8Y045	13	1	1400	2867	1089	136.80	28.30	.05	143.0	2378	98	1363.0	6748.63
8Y046	13	1	2006	3680	1206	152.20	28.60	.05	328.0	3992	145	1035.0	8672.15
8Y047	12	1	463	976	418	49.70	17.50	.05	1149.0	5316	89	118.0	2420.02
8Y048	13	1	990	1796	602	80.60	21.60	1.70	245.0	4254	144	3850.0	4372.04
8Y049	12	1	1029	1954	605	83.00	26.20	.05	2856.0	4473	187	7592.0	4676.13
8Y050	12	1	502	912	351	37.60	15.10	2.70	234.0	4066	224	11065.0	2466.74

Sample	Rock	Occ	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
8Y051	12	1	638	1102	318	19.40	5.90	7.40	1562.0	14517	57	922.0	2582.66
8Y052	12	1	345	583	171	5.50	6.50	5.40	548.0	2385	90	1720.0	1454.42
8Y053	3	0	1853	4076	1104	234.50	56.80	57.00	1642.0	6749	818	26891.0	9908.42
8Y054	3	0	467	949	395	62.00	22.30	1.60	166.0	2876	187	6427.0	2510.81
8Y055	12	0	722	1235	435	50.50	17.60	6.80	797.0	8116	180	2692.0	3186.08
8Y056	12	0	412	707	217	1.70	5.50	2.40	1657.0	2465	49	700.0	1677.83
8Y057	12	0	372	664	221	.05	6.40	11.80	1605.0	8119	54	1622.0	1599.06
8Y058	12	0	108	598	171	11.30	7.60	.05	9155.0	8322	71	6163.0	1172.55
8Y059	13	0	976	1675	581	88.70	24.00	12.40	474.0	9146	94	491.0	4143.53
8Y060	2	0	233	623	338	49.80	23.20	6.40	336.0	11030	286	164631.0	1887.68
8Y061	2	1	477	758	234	49.30	9.60	.05	253.0	5107	68	6846.0	1917.91
8Y062	12	1	327	914	329	38.90	14.20	.05	5917.0	4408	192	43069.0	2195.04
8Y063	12	1	384	832	462	102.40	39.40	10.40	220.0	2235	207	1711.0	2450.09
8Y064	12	1	1242	2205	789	110.60	31.90	.05	97.0	2296	177	355.0	5474.66
8Y065	13	3	1242	2679	1150	196.30	43.30	24.50	375.0	2808	75	1302.0	6488.88
8Y066	2	1	1356	2979	1126	215.20	42.30	10.20	214.0	6844	252	6092.0	7192.11
8Y067	2	1	4419	14979	5426	971.50	125.40	59.50	6.0	2418	407	3058.0	31761.94
8Y068	14	1	1687	5144	2065	284.30	43.10	25.20	.5	1082	143	1198.0	11293.79
8Y069	14	1	1129	2233	839	167.10	34.10	7.90	211.0	3065	150	3497.0	5477.63
8Y070	2	1	1023	2050	730	155.10	39.90	2.30	389.0	3936	149	4449.0	4986.56
8Y071	2	1	1009	2548	1211	270.90	59.50	18.20	28.0	4845	151	6927.0	6320.39
8Y072	14	1	2090	4392	1818	370.50	107.80	44.30	95.0	5078	334	5781.0	10994.52
8Y073	14	1	6393	12374	4182	750.00	191.00	62.60	100.0	2547	449	6953.0	29303.93
8Y074	14	1	4845	7708	2063	390.80	92.00	26.10	157.0	6489	389	7177.0	18638.00
8Y075	12	1	4220	9444	2946	971.70	186.60	75.90	37.0	2063	864	1441.0	22510.22
8Y076	14	1	1367	2459	626	127.40	27.20	6.00	241.0	425	146	129.0	5724.67
8Y077	14	1	2435	4681	1758	316.10	75.50	8.90	80.0	5399	302	5269.0	11502.24
8Y078	14	1	2441	3825	1046	203.90	53.30	8.00	315.0	5493	268	4882.0	9427.84
8Y079	2	1	1435	2272	622	117.00	27.90	6.10	365.0	11782	130	9349.0	5538.67
8Y080	2	1	1450	3115	1343	286.00	74.70	19.40	366.0	5177	298	3473.0	7911.06
8Y081	14	1	2441	4793	1443	228.40	41.30	7.50	476.0	2410	254	1412.0	11075.62
8Y082	14	1	584	1132	146	60.50	14.80	3.80	586.0	116	89	36.0	2450.09
8Y083	2	1	1410	2713	1088	223.40	58.40	16.90	73.0	1983	271	1419.0	6944.50
8Y084	2	1	2145	4399	1716	250.00	54.70	3.80	97.0	2216	293	3227.0	10648.74
8Y085	14	1	3038	8898	3333	542.30	100.40	28.50	15.0	4548	324	3124.0	19566.21
8Y086	14	1	3654	8056	2424	346.30	65.70	22.10	175.0	5555	409	4461.0	18027.95
8Y087	14	1	747	1278	236	66.20	14.90	.05	269.0	273	85	34.0	2922.84
8Y088	14	1	345	733	259	31.50	12.80	.80	283.0	808	71	951.0	1749.26
8Y089	14	1	1458	3120	1122	196.70	50.60	18.30	100.0	4366	298	2662.0	7536.14
8Y090	2	3	1752	3336	1085	149.80	29.80	8.50	581.0	1946	121	4808.0	7788.54
8Y091	14	1	2705	4862	1893	353.50	78.20	19.80	431.0	3947	243	2886.0	12182.75
8Y092	13	1	1934	3321	954	136.20	30.40	9.50	344.0	6559	203	4671.0	7921.07
8Y093	14	1	1499	3255	1407	214.80	41.80	6.90	123.0	2495	183	3275.0	7933.95
8Y094	13	1	1906	3424	1058	173.60	40.00	5.60	93.0	4651	184	5299.0	8161.86
8Y095	2	5	6163	12089	4659	542.20	96.70	33.60	100.0	1628	537	792.0	28968.48
8Y096	1	1	3565	5952	1490	187.20	36.00	8.10	485.0	12605	221	17740.0	13776.97
8Y097	2	5	381	703	240	35.10	6.60	5.70	545.0	984	59	394.0	1719.89
8Y098	2	1	715	1364	589	85.20	19.80	.05	394.0	1184	115	1141.0	3468.33
8Y099	3	3	77	136	21	.05	1.10	7.60	176.0	64	25	1079.0	323.64
8Y100	14	1	4871	8021	2011	184.00	25.10	5.80	140.0	12512	124	11626.0	18314.96

Sample	Rock	Occ	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
8Y101	2	3	162	189	59	.05	1.20	.05	18.0	126	20	206.0	517.82
8Y102	14	1	8676	15408	3938	481.20	75.10	29.70	38.0	8562	364	6174.0	34831.30
8Y103	14	1	6537	12896	3931	467.80	84.20	27.10	57.0	1805	405	605.0	29273.43
8Y104	14	1	5022	9900	2724	379.90	69.30	32.40	104.0	5268	486	8271.0	22399.64
8Y105	2	5	867	1546	520	63.90	15.10	5.50	357.0	2821	97	2179.0	3742.93
8Y106	14	1	4431	8968	3398	425.90	71.70	20.70	28.0	8740	247	10224.0	21086.92
8Y107	14	1	7028	15212	6393	1233.00	292.50	82.80	27.0	11769	932	9859.0	37426.36
8Y108	14	1	2061	3845	1052	131.90	26.30	11.40	19.0	1695	298	908.0	8940.89
8Y109	14	1	1566	2775	888	123.50	26.00	.05	10.0	1248	189	657.0	6693.48
8Y110	13	1	1154	2390	601	78.50	17.90	.05	286.0	2392	102	1793.0	5230.71
8Y111	13	1	63	95	16	3.30	4.50	.20	49.0	612	24	3785.0	248.96
8Y112	13	1	823	1739	587	73.30	24.90	17.40	113.0	658	103	615.0	4050.01
8Y113	14	1	1336	2767	737	89.20	21.10	9.20	26.0	692	111	287.0	6103.81
8Y114	13	1	1091	2534	996	143.10	33.00	.05	58.0	1866	153	1739.0	5951.41
8Y115	14	1	8874	14848	4154	776.80	188.30	87.20	30.0	6963	638	7515.0	35515.88
8Y116	14	1	4459	9024	2408	310.70	52.00	22.60	12.0	1656	294	1848.0	19939.63
8Y117	14	1	3464	6609	2003	240.30	40.80	15.80	36.0	582	207	792.0	15121.69
8Y118	14	1	3585	8068	3033	388.50	64.00	34.00	12.0	1392	280	1421.0	18568.69
8Y119	14	1	1006	2283	788	145.70	35.10	20.40	147.0	1452	209	1062.0	5400.94
8Y120	14	1	1508	3397	1169	205.30	52.20	22.90	77.0	4126	327	3126.0	8043.70
8Y121	14	1	536	1301	392	73.50	14.10	2.60	.5	717	187	122.0	3025.50
8Y122	14	1	1251	3008	1202	203.10	49.00	.05	171.0	4254	274	3373.0	7203.15
8Y123	14	1	2644	6171	2209	254.20	44.30	15.40	136.0	1392	214	1004.0	13890.77
8Y124	14	1	604	1629	417	49.10	9.70	.05	69.0	908	72	274.0	3354.81
8Y125	14	1	729	1660	439	57.40	12.60	1.70	458.0	2621	44	5233.0	3544.48
8Y126	2	5	831	1830	553	106.20	28.50	7.60	392.0	3675	95	2821.0	4152.39
8Y127	2	1	145	282	61	13.10	.90	.05	400.0	1324	25	344.0	635.55
8Y128	12	1	296	533	151	.05	5.10	.05	59.0	5575	60	4450.0	1260.02
8Y129	2	1	158	275	55	28.80	.05	.05	381.0	539	86	3737.0	729.91
8Y130	2	1	152	276	64	12.30	3.90	.05	2539.0	271	30	1316.0	648.79
8Y131	2	5	82	144	14	15.50	1.00	.05	300.0	1146	62	2229.0	387.28
8Y132	12	1	499	1224	726	172.00	57.20	17.50	834.0	5126	197	951.0	3471.01
8Y133	2	5	2339	5359	2458	644.90	170.10	40.50	70.0	2078	623	6349.0	13973.41
8Y134	2	5	579	1033	350	84.40	18.90	3.90	1102.0	1573	125	4172.0	2638.82
8Y135	2	5	377	480	183	36.10	11.30	.05	1149.0	364	68	2008.0	1386.42
8Y136	12	1	174	403	203	12.50	15.40	3.10	1742.0	2140	192	11958.0	1215.43
8Y137	12	1	115	189	50	8.70	1.00	.05	174.0	453	24	299.0	467.07
8Y138	12	1	29505	33400	5330	577.10	71.80	27.20	464.0	15088	304	11843.0	83009.31
8Y139	13	1	475	954	318	48.70	11.40	8.20	136.0	1737	91	1287.0	2294.18
8Y140	12	1	622	1056	398	44.70	25.60	4.20	551.0	2129	222	1506.0	2858.71
8Y141	12	1	1585	2910	1143	229.90	78.70	42.20	627.0	5110	499	23167.0	7805.54
8Y142	12	1	585	1253	432	66.80	22.40	5.40	7564.0	3496	141	32815.0	3017.31
8Y143	2	1	1920	3421	1259	20.30	45.20	15.90	127.0	1209	154	1017.0	8210.91
8Y144	13	1	1890	3167	888	116.20	26.70	.05	462.0	6054	181	10448.0	7537.09
8Y145	2	1	88	144	31	12.70	2.30	.05	1463.0	172	35	1085.0	378.10
8Y146	12	1	211	376	98	.05	5.00	3.40	1087.0	6449	41	7496.0	885.33
8Y147	12	1	211	409	174	6.80	13.90	10.00	1258.0	5606	143	19967.0	1169.74
8Y148	12	1	521	707	181	.80	7.60	.05	479.0	1491	60	254.0	1776.36
8Y149	12	1	460	934	275	.05	6.40	.05	1285.0	5350	34	9724.0	2057.89
8Y150	12	1	341	476	148	.05	3.40	.05	1485.0	7707	98	3515.0	1285.60
8Y151	13	1	544	968	342	45.50	15.60	.05	159.0	4498	60	2664.0	2372.69

Appendix 2

Assay results (Drilling core samples)

Abbrevation

NO.		REO
S12~S19 :	JMS-12~JMS-19	$La_2O_3+CeO_2+Nd_2O_3+Sm_2O_3$
T25~T27 :	JMT-25~JMT-27	$+Eu_2O_3+Tb_2O_3+Y_2O_3$
C01~C32 :	JMC-1~JMC-32	

SAMPLE	Depth~ (m)	Depth (m)	Thick-ness(m)	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
S1201	0.2	7.2	7.0	1638	3483	1414	273.00	76.00	21.80	1813.0	1770	405	9813.0	8791.4
S1202	7.2	11.4	4.2	1574	3698	1793	364.20	83.40	17.40	1031.0	1807	310	5110.0	9410.9
S1203	11.4	16.4	5.0	1233	2671	1104	226.00	58.30	16.30	1292.0	1438	283	5849.0	6721.4
S1204	16.4	21.4	5.0	1183	2508	1046	212.20	60.10	19.20	1542.0	1647	367	9846.0	6491.1
S1205	21.4	26.4	5.0	1473	3165	1282	254.70	64.70	21.70	1960.0	1659	262	6443.0	7837.4
S1206	26.4	31.4	5.0	1812	3501	1205	238.90	64.00	16.40	1112.0	1944	291	5179.0	8569.4
S1207	31.4	36.4	5.0	1082	2333	889	172.90	41.80	10.50	1211.0	2326	135	1611.0	5603.2
S1208	36.4	41.4	5.0	1585	3391	1328	241.30	63.40	17.40	1160.0	2795	315	2738.0	8345.2
S1209	41.4	46.4	5.0	1396	2869	1081	220.30	60.20	17.70	1191.0	1834	279	2736.0	7121.1
S1210	46.4	50.2	3.8	1260	2556	971	195.20	51.70	11.20	986.0	1525	236	4266.0	6347.9
	(10 Samples)			1434	3036	1216	240.28	62.82	17.28	1362.2	1880	294	5567.5	7572.6
S1301	2.3	7.3	5.0	2440	4574	1715	298.90	74.30	16.40	1130.0	1988	496	7197.0	11560.2
S1302	7.3	12.3	5.0	1402	3171	1364	272.60	77.70	22.30	1607.0	4214	407	3723.0	8077.7
S1303	12.3	17.3	5.0	2080	4201	1646	311.90	82.20	24.00	1134.0	7252	509	4657.0	10649.0
S1304	17.3	22.3	5.0	2523	5021	1805	349.10	81.60	24.80	894.0	943	288	3552.0	12123.7
S1305	22.3	27.3	5.0	1572	3500	1522	300.70	73.60	17.50	1199.0	3408	339	827.0	8801.3
S1306	27.3	29.1	1.8	1557	3594	1536	305.20	82.20	23.10	1184.0	7353	451	525.0	9079.4
S1307	31.1	32.9	1.8	1390	3084	1186	218.00	60.80	18.30	1042.0	5384	468	4882.0	7739.2
S1308	42.7	47.7	5.0	1751	3365	1201	249.40	62.80	13.90	604.0	838	192	471.0	8208.4
S1309	47.7	50.1	2.4	1662	3842	1541	330.70	72.50	16.10	448.0	1216	224	1468.0	9234.9
	(9 Samples)			1893	3900	1524	295.79	74.79	19.66	1053.4	3307	371	3205.3	9709.4
S1401	0.6	5.0	4.4	3028	5300	1774	377.00	96.70	23.70	1132.0	2834	384	8042.0	13193.0
S1402	5.0	10.0	5.0	2428	4534	1651	325.20	80.60	18.60	1375.0	3658	210	9008.0	11099.5
S1403	10.0	15.0	5.0	2878	5101	1756	329.10	77.30	20.00	1337.0	2517	237	8033.0	12482.7
S1404	15.0	20.0	5.0	2356	4222	1469	293.20	79.90	18.80	1400.0	1844	480	7702.0	10724.9
S1405	20.0	25.0	5.0	2550	4925	1687	313.50	81.20	28.20	1891.0	1711	443	6897.0	12058.9
S1406	25.0	30.0	5.0	2102	4363	1605	328.60	88.70	30.30	1549.0	1927	609	11066.0	10987.0
S1407	30.0	35.0	5.0	2155	4476	1748	332.90	92.90	28.30	936.0	2074	622	10682.0	11378.8
S1408	35.0	40.0	5.0	3566	7373	2753	531.90	126.60	34.60	2833.0	2328	424	7817.0	17788.3
S1409	40.0	46.7	6.7	2784	5650	2106	398.40	90.80	21.00	2307.0	2032	275	4891.0	13600.1
S1410	46.7	50.1	3.4	914	1964	867	188.40	45.90	12.20	602.0	1532	169	3189.0	4995.2
	(10 Samples)			2530	4906	1782	348.30	87.39	23.85	1597.8	2254	389	7778.2	12096.1
S1501	0.0	5.0	5.0	2318	5167	2179	424.90	110.60	35.10	1636.0	7344	694	10112.0	13147.5
S1502	5.0	10.0	5.0	2499	5658	2486	418.30	109.10	24.10	1277.0	12471	592	12337.0	14169.2
S1503	10.0	15.0	5.0	1638	3442	1491	247.20	70.20	22.00	714.0	13113	557	17783.0	8987.4
S1504	15.0	20.0	5.0	1818	3969	1799	320.20	82.90	27.50	449.0	11354	530	11434.0	10276.3
S1505	20.0	25.0	5.0	1316	2931	1277	228.00	65.20	19.50	487.0	9357	465	15477.0	7584.9
S1506	25.0	30.0	5.0	1668	3406	1441	235.50	64.30	25.80	898.0	5946	439	13152.0	8754.2
S1507	30.0	35.0	5.0	995	2244	1049	189.90	51.80	10.00	525.0	2177	327	7918.0	5853.0
S1508	35.0	40.0	5.0	1324	2838	1204	231.70	66.20	21.00	690.0	3398	410	8616.0	7332.3
S1509	40.0	45.0	5.0	1255	2842	1341	276.40	78.30	16.40	560.0	1987	301	1967.0	7338.1
S1510	45.0	50.1	5.1	1048	2332	1015	201.50	58.10	17.00	547.0	2530	374	6488.0	6072.1
	(10 Samples)			1587	3481	1527	277.21	75.63	21.83	777.8	6959	469	10520.3	8945.7

SAMPLE	Depth (m)	~Depth (m)	Thick-ness(m)	La	Ce	Nd	Sm	Eu	Tb	Nb	Sr	Y	P	REO
S1601	0.3	5.3	5.0	1956	4543	2022	364.30	97.10	27.90	5042.0	9930	598	9077.0	11557.5
S1602	5.3	9.0	3.7	2217	5075	2208	408.90	107.70	32.40	2828.0	4572	454	2646.0	12620.1
S1603	9.0	11.5	2.5	6111	9664	2611	434.70	99.60	24.30	806.0	3368	321	2022.0	23135.3
S1604	11.5	15.8	4.3	9444	15020	3248	498.20	93.30	50.10	1037.0	2984	310	3465.0	34446.9
S1605	15.8	19.1	3.3	2485	5237	2251	452.90	125.80	51.10	4206.0	4192	744	12272.0	13645.3
S1606	19.1	21.2	2.1	2002	4526	1983	332.10	88.50	44.90	5122.0	12449	509	9137.0	11404.3
S1607	21.2	22.2	1.0	1224	2740	1150	233.60	61.60	22.00	2112.0	2595	218	1330.0	6785.9
S1608	22.2	27.2	5.0	4308	7901	2972	542.30	135.10	48.60	1999.0	2451	562	5515.0	19776.3
S1609	27.2	33.3	6.1	1940	4351	2063	425.60	114.80	39.10	2060.0	2085	589	6738.0	11443.8
S1610	33.3	38.3	5.0	1405	3576	2036	460.60	111.00	27.40	791.0	1738	366	3310.0	9572.6
S1611	38.3	43.3	5.0	2542	5435	2248	414.60	100.80	58.10	1228.0	4787	329	1889.0	13359.5
S1612	43.3	48.3	5.0	2300	4729	1909	346.70	90.10	12.50	1619.0	13310	561	13310.0	11964.4
S1613	48.3	50.1	1.8	1808	3933	1784	381.00	100.70	29.30	919.0	2918	665	19163.0	10467.5
	(13 Samples)			3120	6056	2272	423.53	105.69	37.04	2235.0	5217	491	6663.9	15024.4
S1701	0.0	7.0	7.0	6958	13755	5002	865.50	204.50	77.70	5390.0	3039	1799	38023.0	34500.2
S1702	17.3	19.3	2.0	2295	4642	1745	269.20	68.90	15.50	1417.0	25807	576	12902.0	11568.5
S1703	19.3	22.5	3.2	1065	2165	814	146.10	40.30	0.05	1144.0	5130	316	12646.0	5474.5
S1704	22.5	28.2	5.7	374	779	356	85.60	25.00	47.70	852.0	724	136	3657.0	2166.3
S1705	28.2	31.3	3.1	846	1650	615	113.40	33.20	32.10	476.0	1700	441	9064.0	4502.7
S1706	31.3	35.7	4.4	653	1323	541	109.40	32.80	15.40	349.0	1890	183	3546.0	3436.4
S1707	35.7	40.7	5.0	2734	4176	1197	192.40	44.70	21.90	677.0	2599	201	5035.0	10286.2
S1708	40.7	47.0	6.3	1085	2174	779	135.50	37.00	3.70	590.0	1633	225	5569.0	5340.7
S1709	47.0	50.1	3.1	1175	1890	524	109.00	29.30	2.20	861.0	1125	182	5020.0	4704.2
	(9 Samples)			2223	4229	1506	264.79	66.22	28.99	1554.4	3361	520	11879.4	10634.3
S1801	0.6	5.6	5.0	4663	8299	2935	413.60	101.90	30.50	3909.0	15394	623	31068.0	20507.2
S1802	5.6	10.6	5.0	2953	6139	2276	367.90	89.90	40.40	1257.0	10671	419	14873.0	14765.9
S1803	10.6	15.6	5.0	5921	10187	3382	503.20	114.70	21.30	1756.0	4734	465	15846.0	24730.0
S1804	15.6	25.8	10.2	12162	16758	4400	592.50	119.20	31.70	398.0	19468	388	7519.0	41329.8
S1805	25.8	30.8	5.0	4258	7212	2473	362.50	85.90	26.60	1628.0	25649	395	13184.0	17786.7
S1806	30.8	35.8	5.0	12163	16962	4388	605.10	120.00	4.80	1678.0	43873	492	16109.0	41684.2
S1807	35.8	40.8	5.0	10753	15212	4230	641.80	135.00	40.60	1130.0	31665	547	24816.0	37868.0
S1808	40.8	45.8	5.0	8275	13921	4448	650.30	138.50	45.40	1213.0	17758	662	25194.0	33795.7
S1809	45.8	50.2	4.4	8657	13421	4104	568.10	122.60	39.50	658.0	33061	543	23312.0	32957.0
	(9 Samples)			8207	12493	3702	529.54	114.61	31.15	1407.5	22031	491	17837.0	30690.8
S1901	2.0	3.0	1.0	2886	5884	2324	405.60	97.20	27.80	2773.0	1539	455	3142.0	14513.5
S1902	3.0	7.6	4.6	5342	8578	2903	395.00	81.20	19.90	1254.0	9119	362	4100.0	21219.7
S1903	7.6	9.6	2.0	3824	6233	1783	321.00	77.30	14.60	1043.0	17313	337	6926.0	15125.3
S1904	12.7	17.7	5.0	3263	5278	1596	259.70	69.80	19.70	981.0	1616	371	6243.0	13045.7
S1905	17.7	22.7	5.0	2131	3389	1057	175.40	51.30	14.10	620.0	4141	265	6827.0	8509.5
S1906	22.7	28.3	5.6	2836	4432	1324	216.90	61.20	8.50	745.0	2212	378	7103.0	11125.2
S1907	28.3	33.3	5.0	505	911	331	61.60	23.20	4.50	716.0	976	100	1028.0	2327.5
S1908	33.3	38.3	5.0	1127	2064	681	113.50	30.40	7.60	710.0	874	107	1729.0	4962.1
S1909	38.3	43.3	5.0	593	1150	425	75.30	27.10	10.30	826.0	887	90	1786.0	2848.2
S1910	43.3	48.3	5.0	360	778	366	67.60	25.50	1.90	737.0	708	105	3049.0	2047.9
S1911	48.3	50.3	2.0	1567	2753	1017	188.60	50.80	10.50	648.0	1117	171	6972.0	6911.5
	(11 Samples)			2080	3451	1128	181.90	48.81	11.23	863.8	3070	231	4267.4	8566.5