International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET)

ISSN 2455-4863 (Online) www.ijisset.org *Volume: 4 Issue: 1 | January 2018*

Occurrence of Carbonatite-Lava and Basalt in the Vicinity of Palayam, Tamil Nadu, India

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Abstract: *Exposure of very fine-grained black coloured vesicular carbonatite–lava with pinching and swelling structure of 75-125 x 0.1-2 cm size hardly extending for maximum depth of 50 cm in granite gneiss, quartzite and in crystalline limestone is seen in the vicinity of Palayam (10°42'32"N : 78°08'06"E), Tamil Nadu. It is composed of very low content of SiO2, Al_2O_3, FeO, MgO Na_2O and K_2O. More than 80% volume content of carbonate minerals is found. It has notable enrichment of normative apatite, fluorite, anhydrite, salts of chlorides and carbonates of sodium and potassium. Portlandite is present in carbonatite-lava from 1-2 km north and south of Alambadi limestone mine near Palayam. Number of globular calcite (0.1 to 0.5µm) is present on calcite platelets. Linear arrangement of exsolved blebs >0.3 µm of portlandite in calcite plate is observed in carbonatite-lava. Vesicles are surrounded with rims of calcite needles and plates. A trend of linear negative correlation of co-existing calcite and portlandite is seen in carbonatite-lava. A sample of basalt with white specks of globular calcite is collected from a well-dump material found 2 km north of Mylampatti. The effects of volatile degassing by presence of vesicles, primary cracks and micro-pits drastically change composition of basalt and carbonatite-lava. EDAX analyses at different sites of basalt widely vary in composition from picro-basalt, basalt, trachy-basalt, basaltic andesite and trachy andesite. Globule of calcite encircled with zeolite rim might have been an evidence for immiscible separation of minerals in basalt and also for basalt and carbonatite-lava. Association of carbonatite-lava with silicate-perovskite indicates their mantle source.*

Keywords: *Carbonatite-lava, Basalt, Silicate-perovskite, Tamil Nadu, Micro-volcanic flows, Volatiles degassing.*

1. INTRODUCTION

Occurrence of carbonatite-lava in association with basalt is rare. In Tamil Nadu it is reported from Kudangulam [1], Dharangambadi-Karaikal coast [2] and in Sivamalai alkaline complex [3]. The present report is yet another one. The association of carbonatite-lava with silicate perovskite [4] is co-incidence in the vicinity of Palayam *(10°42'32"N: 78°08'06"E)* near Karur Town [4]. Magmatic origin of carbonatite was widely accepted only after the eruption of natro-carbonatite-lava from vents of Oldoinyo Lengai, East Africa [5]. Portlandite co-existing with calcite is a rare occurrence in carbonatite-lava in this area. Portlandite was reported from carbonatite massifs of Eastern Sayan, [6] Kovdor [7] and Vuoriyarvi [8] in Russia and Phalaborwa massif, in South Africa [9].

2. FIELD STUDIES

Early Pleistocene calcareous conglomeratic sandstone carries bimodal volcanic grey and pink carbonatitic bombs, lapillus, pisolites and ashes covering over an area of 90 km² north of Thiruvalangadu [10] Tamil Nadu

Fig.1 *Sites of field exposure of carbonatite-lava (1, 4, 5, 6) in crystalline limestone, basalt (2), carbonatite-lava associated with silicate perovskite in granite gneiss (3), portlandite bearing carbonatite-lava (6) and a silica enriched carbonatite lava in quartzite (7) are shown*

Carbonatite-lava inclusions of dark-black rock in Mio-Pliocene shell limestone in Kudangulam, Sattankulam and Manappadu in association with soda-trachyte, basalt and carbonate-tephrite along southern coast of Tamil Nadu [1] is the first sample collected by the author during his field traverse along the coast of Kudangulam. Similar occurrence is found along the Dharangambadi-Karaikal coast [2]. South of alkaline complex of Sivamalai [3] in two ring-fractures filled with carbonatite-lava. Sr enriched Barite occurs in this lava. Beside these, dark-black thin films of carbonatite lava are found in Pandalgudi Podupatti, Eppodumvendran and Singikulam limestone exposure. Porphyritic carbonatite-lava is exposed in Podupatti in the limestone and in feldspar-rich pegmatites. Thin film of carbonatite-lava is found at intergranular boundaries of feldspar in pegmatite of Siddhi-Vinayaka quarry at Saidapuram. Transformation of alkali-feldspar into calcite is seen in Lakshimi-Narayana pegmatite mine in Saidapuram along Gudur-Nellore muscovite schist belt. Kankar and floats of silicate perovskite are found in this muscovite-pegmatite belt.

Linear carbonatite-tuffs named as tufaceous limestone running several hundreds of meters are also seen, in southern parts of Tamil Nadu. However, more detailed field and laboratory studies are required to confirm to prove such tufaceous limestone as altered carbonatite-tuff. Extensive kaolinization is marked in Muttam, Kudangulam, Idinthakarai, Vijayapathi [1], Kanakkankulam, Tisaiyanvilai, Thiruvambalapuram, Surankudi and Vembar Region due to the effects of emplacement of basalt and carbonatite-lava and alteration of feldspar granite gneisses to kaolin by releasing transparent quartz. Relicts of carbonatite-lava are found in Malapuram (Madurai), Singikulam, Uttumalai, Sendamaram and Sambavarvadakarai in association with silicate-perovskite. Pyrochlore prism is observed at a periphery of a vesicle in carbonatite-lava of Kudangulam. Relicts of carbonatite lava are found in tuffs of Malapuram and in west and south of Kangayem. Floats of carbonatite-lava were collected from several parts of Tamil Nadu such as Sekkanurani, Manappadu, Sattankulam, Tisaiyanvilai, Uvari, Kudangulam Walaiyar Ettimadai, Sankaridurgam Pandalgudi limestone exposures. Iron rich carbonatite-lava 10x1cm is found in granite gneiss in association with crystalline gypsum deposit in Thalaikattupudur near Vilathikulam. Gypsum deposits are found SW of Sivamalai alkaline complex. Silicate perovskite [4] occurs in association with carbonatite-lava occurring in Nalluranpatti 2 km south of Mylampatti.

Most exposure in the vicinity of Palayam carbonatite-lava exhibits pinching and swelling structure. Size of 75-125 x 0.1-2cm with maximum depth > 50cm in granite gneiss, quartzite and in crystalline limestone is seen in the vicinity of Palayam, Tamil Nadu. It has no root. Chilled margin is limited to 1 or 2mm enriched with ferric constituents. The outer surface of lava is appeared to be rugged, jagged and rough. Pits, vesicles and patches of varying sizes in calcite are seen Samples are very fresh without any alteration in Nalluranpatti and Mylampatti. Very dark fine-grained carbonatite-lava of 50x10cm is exposed in limestone body 1 km north of Alambadi quarry. In quartzite of Perumalmalai, slightly brown coloured fine-grained lava is exposed along fold axial planes of quartzite as lenses with maximum width of 10cm. Most other places floats of carbonatite-lava are collected in Jimmi mine, Dolipatti, Seelanayakkanpatti, Meenakshipuram and Kasipalayam in the vicinity of Palayam.

3. PETROGRAPHIC INVESTIGATION

Basalt occurring 2 km north of Mylampatti is a very fine-grained rock. In hand specimen white specks and thin films of calcite and vesicles of 0.5-2mm is found. Under thin section under polarizing microscope, it exhibits ophitic texture with intersertal grains of augite and feldspar. The groundmass is composed with same mineralogical and chemical composition (Table 1, 2 3) of that of phenocrysts. Globules of calcites of varying sizes from 750 to 1000μm dimensions are seen surrounded by rims of zeolite. Circular pits of 0.5μm are seen on the outer surface of globular calcite. Vesicles varying from 1 to 10μm are found with varying depth extensions from 0.1 to 5μm. Platelets of zeolite 2 x 0.4μm are commonly seen one over other. Needles of zeolite with length and breadth ratio exceeding over 8 occur. Almost equal proportions of clinopyroxene and feldspar are seen. Normative anorthite content in plagioclase (Fig. 2) ranges between ab_{2-49} and an_{98-51}. Significant amount of normative [11] sanidine / anorthoclase is estimated in alumina poor and alkali rich sites of basalt by EDAX analyses. The basalt is composed with normative fluorite, halite, alkali-carbonates, anhydride, calcite and quartz. Presence of normative sillimanite and cordierite indicates that basaltic and carbonatite-magmas were subjected to extensive degassing. Rhombic calcite plates of 15x12 μm are deposited one over the other at inner side of globular calcites. Along inner sides of primary cracks and platelets of mineral grains minute vesicles >0.5μm are present through which large quantities of volatiles were escaped. The composition of basalt in alkali-silica diagram widely varies from picro-basalt, basalt, trachy basalt, basaltic andesite and trachy andesite [12]. Thin section of carbonatite-lava shows presence of very fine-grained calcite often >0.2mm. Vesicles of maximum

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ISSN 2455-4863 (Online) www.ijisset.org Volume: 4 Issue: 1 | January 2018

Table1: *Wet-gravimetric chemical composition of basalt and carbonatite lavas at 2km north and south of Mylampatti in the vicinity of Palayam*

	1	2	3	A	B	C	D
Basalt	my	my	my	Carb Nal	n	m	m
SiO2	47.82	43.45	52.24	13.36	11.42	9.49	14.46
Al2O3	12.96	9.87	8.22	4	4.89	5.15	3.14
Fe2O3	8.20	9.01	12.99	0.76	0	0.08	2.05
FeO	7.18	9.99	4.74	0.3	1.76	0.66	0.67
MgO	2.27	5.30	5.96	4.2	2.1	13.43	0.82
CaO	12.13	12.76	9.63	42.04	42.96	31.15	40.38
Na2O	2.47	1.96	0.19	0.52	1.48	0.4	3.51
K2O	0.01	0.35	0.17	0	1.13	0.36	0
TiO2	1.72	1.58	1.98	0	1.13	0.01	0.36
P2O5	0.06	0.00	0.00	0	0	0	0
SO3	0.00	0.00	0.91	0	0	0	0
CO2	4.16	4.20	2.06	35	35.2	39.12	34.2
	98.98	98.47	99.09	100.18	102.07	99.85	99.59
ap	0.46						
il	2.47	2.31	2.95	0.00	1.43		0.50
mt	1.66	1.62	1.36	0.05	0.05	0.05	0.20
anh			2.48				
nas							2.07
nak2c							1.67
cc	10.90	11.19	5.55	80.36	80.33	86.12	77.64
cpx	28.17	47.09	42.29	3.54			
cord				9.16	6.52	2.32	
sil					0.15	4.89	
san						4.21	
pl	47.90	37.80	25.10	3.85	10.25		15.65
ne					0.87		
qz	8.43		20.26	3.04		2.42	2.07

size of 0.5mm are seen. EDAX images show the lava has hypidiomorphic granular texture. Along periphery of vesicle slightly coarse grains of calcite of 0.2-0.3mm are grown as rims in carbonatite-lava. Along hair-line cracks, fissure, flow-bands and other weak-planes similar type of large grains of calcite are recrystallized. Under higher magnification calcite aggregates 20x5µm are seen. Globular calcite 0.5µm dimension is seen on the columnar calcite plate. Rhombic calcite of 3µm is present. Corroded and concave calcite plate of 100x50µm carries globular calcite of 5µm. It carries 3 globules inside in linear direction. Some calcite plate 500µm length shows outward dipping platelets of domal shape. The thickness of calcite plate ranges between 3 and 10µm. Horn like projection of calcite plate 5x4µm with extending horns of 4x2µm are seen. A vesicle of 15µm is seen surrounded with calcite platelets encircling the vesicle. The thickness of the calcite plate hardy exceeds to 0.5µm and the length extends 5µm. The depth of the vesicle hardly extends over 4µm. Needles of calcite with maximum length and breadth ratio exceeding over 8 is seen. Numerous pits >1µm produce rough and irregular surface on calcite plates adjacent to primary cracks. Globule of calcite is found within the vesicle. Rows of exsolved blebs of portlandite >0.3µm in calcite plate of 3µm are observed. A tubular pit of 50x5µm is seen in a calcite plate. Gas cavity of 150x60µm is found among calcite plates. Some interconnecting vesicles and primary cracks are seen. Shrinkage cracks and folded flow-

Table 2: *EDAX analyses of basalt from 2 km north of Mylampatti*

Basalt	4	5	6
SiO2	50.49	52.02	57.07
Al2O3	19.53	19.09	20.63
FeO	9.32	11.43	4.62
MgO	2.90	2.23	1.59
CaO	3.39	4.24	3.84
Na2O	5.45	5.14	5.79
K2O	1.05	1.48	1.75
TiO2	1.03	1.21	0.58
P2O5	0.70	0.24	0.00
F	1.05	0.78	0.67
Cl	0.07	0.04	0.09
SO3	0.19	0.00	0.00
CO2	4.85	2.11	3.36
	100.00	100.00	100.00
ap	1.45	0.44	
mt	0.91	1.16	0.43
anh	0.21		
caf2	4.46	3.42	2.85
nakcl	0.21	0.11	0.21
cc	11.81	5.30	8.16
cpx	0.16	9.94	
cord	27.80	23.74	19.48
sil			4.89
san	50.78	46.77	58.40
pl		2.98	
ne		2.26	
sp		3.87	
qz	2.20		5.58

bands are observed. Interpenetrating needles of calcite are commonly found. Concave plates of calcite are observed in carbonatite exposure of Nalluranpatti and Mylampatti. They show normative alkali feldspars, sillimanite cordierite and quartz [11].

The carbonatite-lava near Alambadi is composed, high proportions of normative portlandite and calcite. Some sites of mineral grains are composed entirely of portlandite. EDAX analyses were made at different sites to trace compositional variation of portlandite (Table 4, 5a 5b and 6 Fig:-5-8). Prisms of portlandite 6x3µm with length and breadth ratio exceed over 2. Smaller prisms of 2x0.5µm are also present. They often interpenetrate into calcite plates. Globular calcites of varying sizes from 1 to 0.1µm are found on the plates and intergranular boundaries of calcite. Vesicles of 5x3x3µm are found in between platy layers of calcite. Some lens-like vesicles are so large to 10x3x3µm found between layers. Calcite- plates grown around at top of vesicles are curvilinear in shape in carbonatite-lava. The shape and size of vesicles and their depth widely vary. The volume percent of vesicles range between 10 and 15%. Calcite platelets are oriented parallel to flow-bands. Calcite 4x3µm is rhombus in shape. Vesicles and intergranular boundaries of mineral grains are irregular in shape. Tubular and telescopic growth of skeletal portlandite crystal (Fig. 3) of 20x5µm size is seen. Two components variation diagrams are drawn for geochemical interpretation. Lava in quartzite is contaminated with silica but significantly enriched with normative ilmenite, magnetite apatite, anhydrite, halite, fluorite and alkali carbonates.

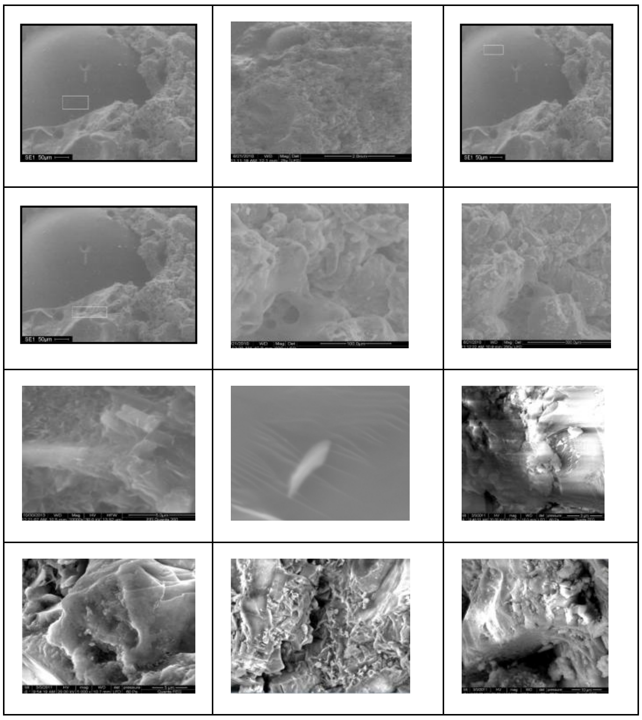

Fig. 2: *Scanning Electron Images of Basalt collected 2km north of Mylampatti in a well-dump.*

4. GEOCHEMICAL STUDIES

Wet-gravimetric chemical analyses were made for fine-grained basalt and carbonatite lava. Oxidation ratio (Fig, 4). Fe^3/ (Fe^3+Fe^2) is higher >0.5 (Table:-1 and 4) in most of the rocks. The basalt is composed of 5-11% of calcite. Volatiles of P_2O_5, F, Cl, SO_3 and CO_2 and by escape of these constituents' vesicles are present in basalt and carbonatite-lava. Total alkali-silica (TAS) diagram [12] shows that composition of basalt varies from picro-basalt, basalt, trachy basalt, basaltic andesite and trachy-andesite due to site specific magmatic degassing, viscosity changes and changes in eruption styles. Notable amount of Na_2O+K_2O are present in basalt and carbonatite lava. K_2O is significantly lower than Na_2O. Clinopyroxene and feldspars are almost equal in proportions. Normative [10] cordierite and sillimanite are present in these rocks. Calcite is present over 77% in carbonatite-lava.

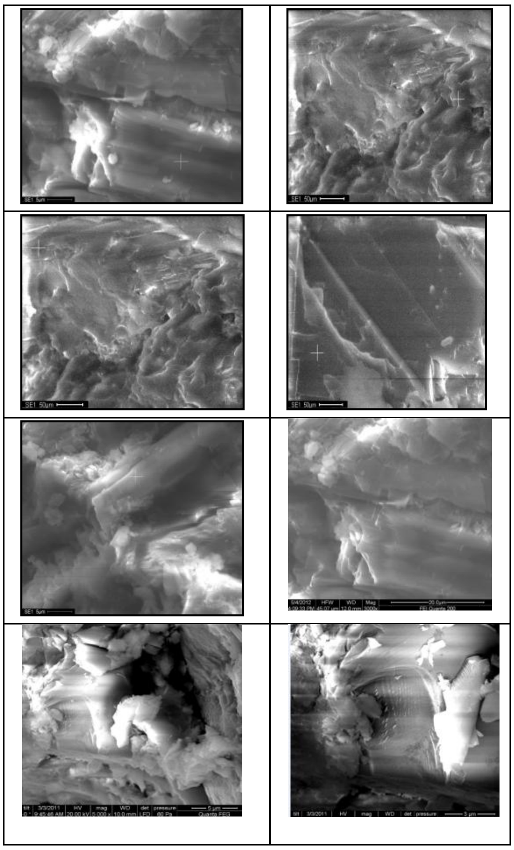

Fig. 3: *EDAX images of Carbonatite-lava 2km north of Mylampatti and Nalluranpatti 2km south of Mylampatti*

The degree of oxidations in these rocks increase (Fig. 4) with alkalis. Al ions directly increase with Si ions. Significant amount of anhydrite, fluoride, chloride and alkali carbonates are present in basalt linear positive correlation exists in most of these bi-components variation except Na_2O+K_2O against CaO% (Fig. 5). Trends of chemical variations are very similar in basalt and carbonatite-lava Fig:-5, 6, 7, 8. Similar positive

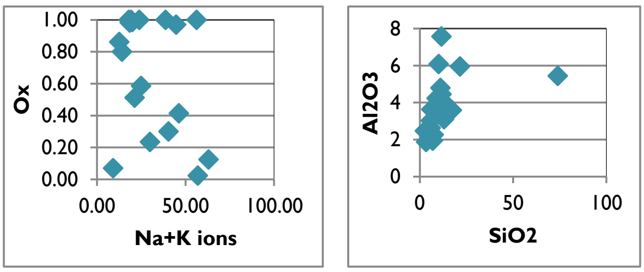

Fig 4: *High-degree of oxidation of these rocks against alkali ions indicates volcanic origin of these rocks of Alambadi and Perumalmalai.*

correlation trends are seen in carbonatite-lava. Pitted appearance on calcite plates adjacent to primary cracks indicates that a large quantity of volatile constituents was escaped from carbonatite-lava. There might have been a liquid immiscible relationship between the basalt and carbonatite-lava [13]. There are a number of recent carbonatite lava and basaltic extrusions in Tamil Nadu [14]

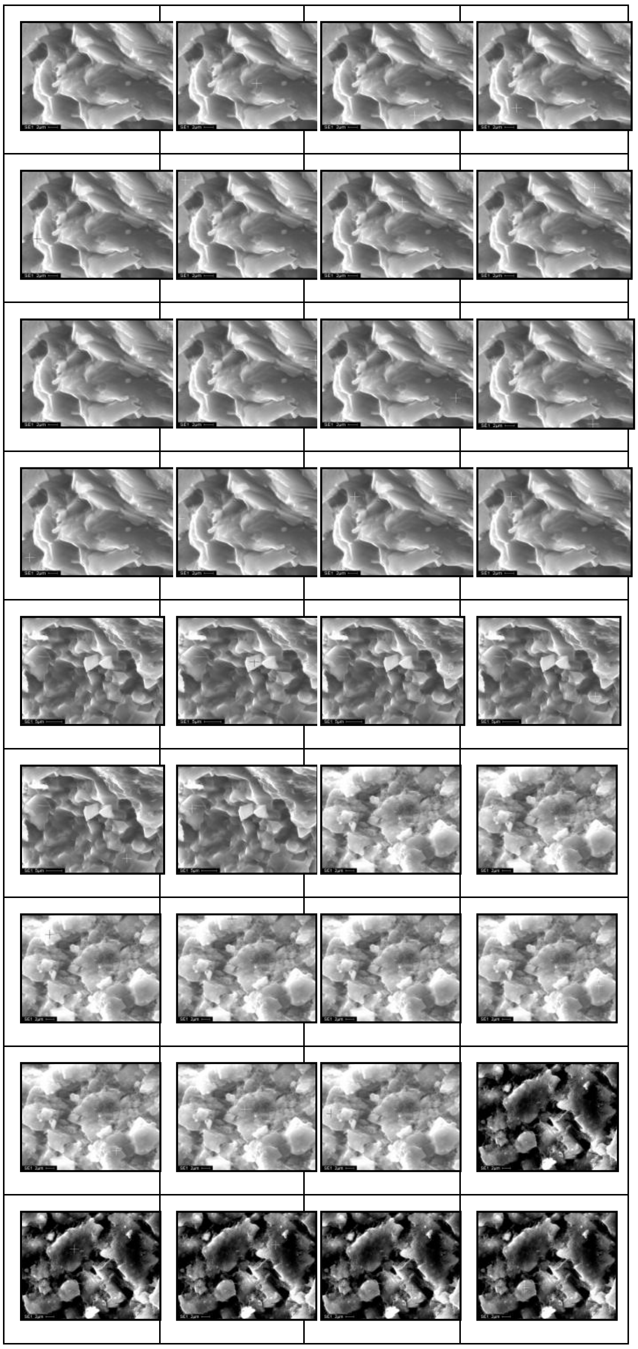

Fig.4: *Scanning Electron Microscopic images to trace compositional variation of portlandite carbonatite-lava from Alambadi. Interpenetrating prisms, platelets and aggregates of portlandite is seen.*

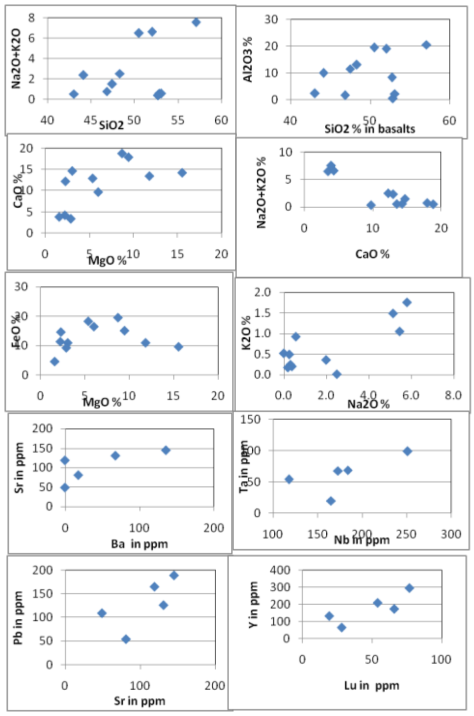

Fig. 5: *Chemical variation diagram for basalt by wet-gravimetric chemical analyses of samples collected in the vicinity of Palayam near Karur Town.*

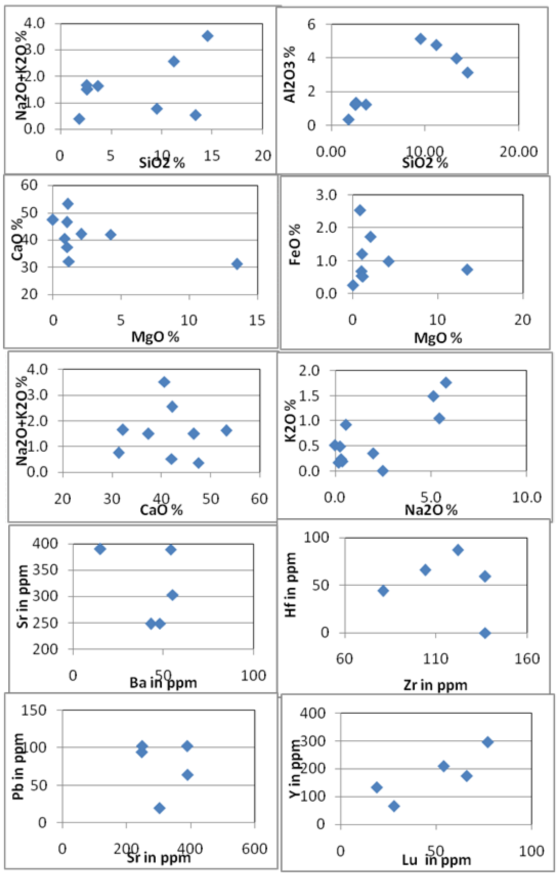

Fig. 6: *Chemical variation diagrams for carbonatite-lava at Nalluranpatti and Mylampatti.*

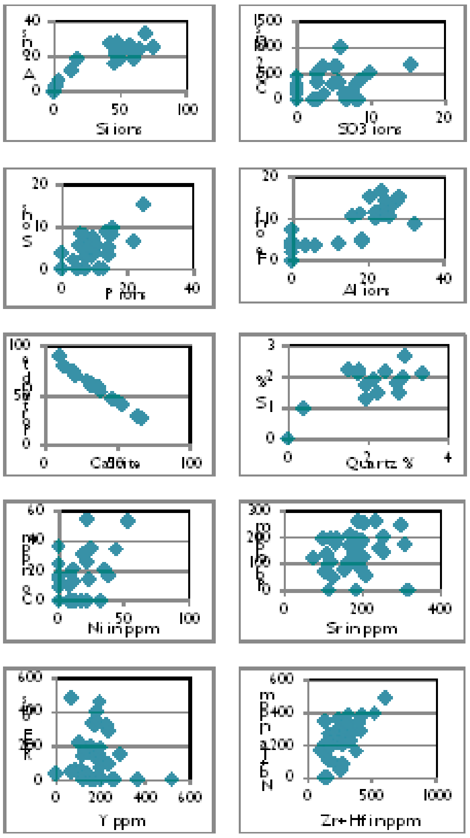

Fig. 7: *Chemical variation diagrams for portlandite bearing carbonatite-lava from Alambadi.*

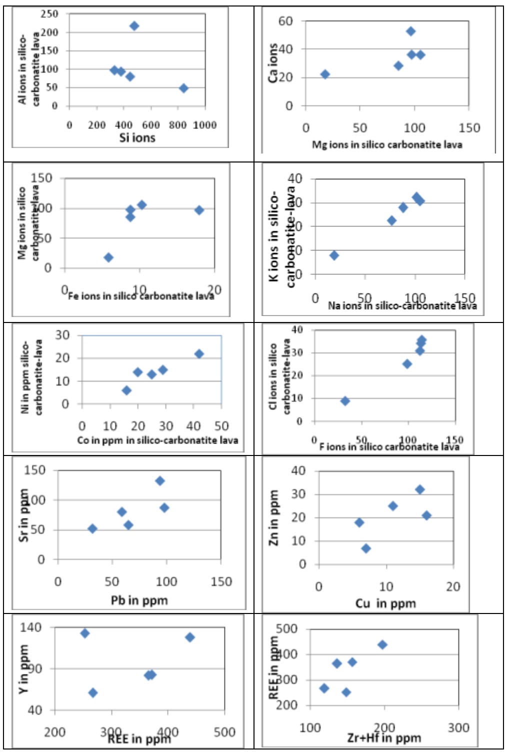

Fig.8: *Chemical diagrams for silico-carbonatite in quartzite in Perumalmalai. Alumina decreases with increasing of silica. Most other constituents show positive linear variations.*

Carbonatite-lavas from Alambadi and Perumalmalai show positive linear correlation between respective components. They are composed of portlandite and calcite. Portlandite against calcite shows perfect linear negative variation (Fig. 7). In order to trace compositional variation of portlandite and calcite a number of individual grains were analyzed. Positive variation (Fig. 7) is seen between Fe and Al. Co against Ni and (Nb+Ta) vs (Zr+Hf). The silico carbonatite-lava in quartzite is distinctly enriched in silica and alumina. MgO against CaO exhibits similar variation (Fig.8). They have linear negative correlation between Na_2O+K_2O and CaO and portlandite and calcite. They have enriched with volatile constituents over CaO, MgO, FeO. The excessive CO_2 reacts or contaminates with wall-rock with enrichment of Si and Al ions. However, it anonymously enriched with P_2O_5, SO_3, F, Cl, CO_2 and H_2O. The last one is the major unknown volatile component exceeding >90% volume of volatiles..

Table 3: *EDAX analyses of basalt and carbonatite-lavas from Nalluranpatti and Mylampatti*

	7	8	9	10	11 E	F	G	H	I	
SiO2	43.04	52.85	46.81	53.06	47.45	3.43	2.56	2.62	1.82	2.56
Al2O3	2.34	0.52	1.64	2.20	11.53	1.17	1.24	1.36	0.36	1.28
FeO	19.64	9.68	15.19	11.02	11.02	1.12	0.68	0.54	0.26	0.52
MgO	8.73	15.56	9.46	11.83	3.06	0.99	0.99	1.03	0.00	1.15
CaO	18.86	14.29	17.98	13.51	14.71	49.60	46.54	37.33	47.41	32.15
Na2O	0.00	0.38	0.26	0.31	0.57	0.64	0.77	0.91	0.00	1.10
K2O	0.52	0.20	0.49	0.24	0.92	0.88	0.72	0.59	0.38	0.56
TiO2	0.73	0.51	2.79	0.67	0.67	0.38	0.36	0.45	0.00	0.27
P2O5	0.00	0.00	0.00	0.00	0.37	1.98	2.00	2.55	1.43	2.40
F	1.63	2.06	1.36	3.95	1.00	0.55	1.05	1.28	0.00	1.28
Cl	0.13	0.00	0.17	0.00	0.78	0.52	0.49	0.45	0.13	0.42
SO3	0.00	1.01	0.00	0.00	1.34	1.33	1.43	1.26	0.33	1.22
CO2	4.37	2.95	3.82	3.19	6.59	37.41	41.16	49.63	47.88	55.08
	100	100	100	100	100	100	100	100	100	100
Mo	80	0	80	16	167					
Sc	38	0	20	0	10					
Zn						31	28	26	0	25
Ba	136	0	18	0	68	54	55	43	15	48
Sr	145	119	81	49	131	389	303	248	390	249
Pb	189	165	54	109	126	102	20	94	64	102
V	28	10	11	7	14	22	17	19	0	18
Cr	26	17	21	8	13	23	23	17	0	19
Ni	15	0	10	17	24	20	18	19	0	26
Co	43	35	23	9	23	31	30	26	0	21
Rb	183	90	69	52	127					
La	54	29	41	8	40	85	82	71	0	75
Ce	0	16	22	11	36	52	61	51	0	41
Nd	57	31	16	0	33	64	47	44	0	50
Eu	136	56	109	46	57	68	76	75	0	66
Yb	40	80	0	0	27	54	56	43	33	31
Lu	77	66	28	19	54	59	63	51	15	64
Y	295	174	66	133	209	92	82	70	57	31
Ta	99	69	20	54	68	105	60	62	24	60
Nb	251	184	165	118	173					
Hf	50	50	32	0	37	87	66	59	0	44
Zr						122	104	137	137	81
	7	8	9	10	11 E	F	G	H	I	
ap					0.72	3.77	3.84	5.13	2.98	6.25
il	0.56	1.06			0.33	0.70	0.72	0.60	0.45	0.55
mt	1.62	0.75	1.31	0.94	0.95	0.05		0.06		0.00
anh		1.38			1.89	1.71	1.84	1.93	0.45	2.06
caf2	7.19	8.62	6.14	16.34	4.46	2.21	4.15	6.09		6.94
nakcl	0.45		0.57		2.45	1.51	1.43	1.57	0.45	1.65
nak2c		0.48				3.77	2.00	3.56	0.34	3.71
cc	11.04	6.81	9.89	7.64	16.71	80.90	78.55	71.65	90.94	68.59
al2c3							3.07	4.10	1.01	4.33
sic							4.40	5.31	3.38	5.91
cpx	70.12	66.11	71.65	50.58	18.27					
cord						4.87				
san	1.95	2.66	2.96	0.55	4.46					
pl	5.57			6.36	29.25					
qz	1.51	12.13	7.48	17.59	20.50	0.50				
	100	100	100	100	100	100	100	100	100	100

Table 4: *Wet-gravimetric analyses of Carbonatite lava samples around Palayam, near Karur Town*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Palayam	pal	pal	pal	sillanaya		Dolipatti	Kasplm	kasi	doli	Doli	Meenashi	alam	dol	palay	alam	alam	Perumal
Alambadi Gravimetric Analyses						Ammapatti	Dolipat	Kasplm	dol					pisolitic	pisoli			
	23	25	201	202	226	307	315	316	365	375	391	535	811	820	822	825	826	18
SiO2	2.71	11.59	6.92	13.75	21.51	5.82	3.36	5.87	8.97	11.04	7.46	11.67	17.17	12.99	6.17	10.11	13.00	73.94
Al2O3	2.47	7.57	1.94	3.34	5.95	2.63	1.87	3.02	4.23	4.79	2.26	4.45	3.59	3.10	3.63	6.08	4.01	5.44
Fe2O3	0.06	0.42	0.34	0.18	0.22	0.03	0.11	0.20	0.90	0.74	1.07	0.95	1.45	0.80	0.36	0.42	0.64	4.51
FeO	0.00	0.36	1.00	1.14	0.14	0.36	0.14	0.42	0.00	0.00	0.00	0.00	0.21	0.01	0.01	15.81	0.01	1.01
MgO	0.85	1.27	1.29	1.71	0.21	6.20	0.83	5.65	3.31	7.92	1.20	2.48	0.88	2.13	2.15	15.81	1.53	1.93
CaO	51.64	41.07	46.78	42.48	39.48	44.54	60.29	42.08	46.34	47.52	48.15	42.74	41.94	44.79	49.24	26.91	44.30	5.41
Na2O	1.02	0.65	0.80	1.45	0.23	0.28	1.43	0.94	0.56	1.53	0.35	0.16	0.21	0.49	0.60	1.63	0.36	0.12
K2O	0.27	0.01	0.19	0.76	0.82	0.00	0.00	0.47	0.27	0.32	0.31	0.66	0.27	0.19	1.19	0.20	0.32	0.48
TiO2	0.01	0.01	0.71	0.00		0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.57
CO2	41.06	37.43	36.52	34.10	31.22	40.02	41.64	40.64	36.58	25.80	39.29	36.45	34.44	34.61	37.83	36.58	35.44	4.38
LoI	0.00	0.00	1.12	1.41	0.38	0.81	0.31	0.22	0.12	0.12	0.11	0.84	0.07	0.57	0.06	2.24	0.54	1.75
	100.09	100.38	96.49	98.91	99.78	99.89	109.68	99.30	101.17	99.67	100.10	99.56	100.17	99.12	101.19	113.56	99.62	97.79

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	23	25	201	202	226	307	315	316	365	375	391	535	811	820	822	825	826	18
il			0.95															0.83
mt			0.05	0.1		0.05		0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	1.19	0.05	0.41
cpx	7.72		11.41	3.85														
ol			0.42	0.31														
nak2c		1.61				0.69	3.16	2.97	1.80	4.01	1.36	1.48	1.13	1.57	3.28	3.79	1.48	
cc	92.28	77.88	87.17	79.43	73.82	89.49	84.51	88.95	81.64	57.1	89.24	83.32	79.94	81.09	83.2	70.57	81.31	11.69
port						2.38	8.07		4.94	24.75	0.86	0.82	0.52	4.39	4.82	11.81	2.05	
al2c3		5.54						0.45										
sil		7.86		0.15	6.72	3.87	2.57	4.11	6.34	7.15	3.34	6.68	5.42	4.86	5.32	7.89	6.09	
cord					1.09													23.38
san				16.16	6.19													2.6
qz		7.1			12.18	3.52	1.7	3.47	5.24	6.95	5.15	7.65	12.89	8.05	3.33	4.76	9.01	61.1

The positive correlation trends are seen between respective bi-components of Na_2O+K_2O vs SiO_2, Al_2O_3 vs SiO_2, CaO vs MgO, K_2O vs Na_2O, Sr vs Ba, Ta vs Nb, Pb vs Sr and Y vs Lu are seen in Fig. 5. These trace elements are supposed to be considered to relate on crystallization on Molybdenite and other sulphides. Similar correlation trends are seen in Fig. 6, 7 and 8. The slope of the Ca in basalt and carbonatite-lava is getting more negative as Na+K ions increase leading to fractionation of alkali-silicates. Similar trend is observed in between portlandite and calcite. Most trace elements present in basalt and carbonatites from Nalluranpatti and Mylampatti have similar differentiation trends.

5. DISCUSSION

Very small exposures carbonatite-lava, basalt and silicate-perovskite [4] in field do exist on the surface of the Earth similar to mode of occurrence of some pegmatites and as relicts of volcanic extrusions. The mechanism of extrusion under ideal condition without any friction and loss of heat energy is well explained [4] for rapidly ascending mantle plumes under ideal state. The presence of globular inclusion of calcite rimmed with zeolite in basalt and on calcite plates, vesicles and intergranular boundary of calcite in carbonatite-lava might have been due to liquid immiscible [13] relationship between basalt and carbonatite melt, the linear positive correlation is shown in Fig. 5, 6, 7 and 8 indicates magmatic differentiation and fractionation of mineral grains. Notable traces of Pb, Sr. Cu, Co, Ni, Cr are present in basalt and carbonatites. Mo was estimated only for basalt and it varies between 80 and 167ppm.

In an experimental system CaO-CO_2-H_2O a minimum temperature ranges between 675^o and 683^{o}C for distorted prism liquidus surface for crystallization of co-existing portlandite and calcite at 1kbar [15]. Portlandite crystallizes progressively increasing state of H_2O/CO_2 in volatile phase at late magmatic condition. Portlandite crystallizing at hyperalkaline state (pH $\geq$13.2) it correspondingly concentrates Na and K [16, 17, 18]. A negative linear correlation between normative portlandite and calcite reveal solubility of calcite and portlandite increase in NaCl-H_2O magma, thereby crystallization of alkali-rich calcite and portlandite takes place at late stages.

The eruption and evolution of natro-carbonatite is secondary only after fractionation from common carbonatite magma [19], therefore, calcite in carbonatite magma enriched with Na+K during evolution of carbonatite magma [16, 17, 18] at late stages of differentiation and fractionation. Further, presence of normative cordierite, sillimanite and quartz in carbonatite-magma indicates that huge quantities of volatile phase particularly H_2O and CO_2 were easily escaped from low viscous carbonatite magma during rapid extrusion changing original composition according to its eruption style.

Table 5a: *EDAX analyses of calcite and portlandite bearing carbonatite-lava from Alambadi*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SiO2	1.05	0.00	0.00	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	0.93	0.00	0.00	0.00	0.31	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FeO	0.32	0.00	0.00	0.00	0.26	0.00	0.25	0.53	0.21	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.26
MgO	0.71	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	63.40	71.60	99.81	100.00	91.52	84.82	53.27	97.27	98.75	98.80	100.00	98.47	100.00	80.55	98.40	98.40	98.19	98.55	99.07
Na2O	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.78	0.47	0.19	0.00	0.75	0.36	0.36	1.19	0.92	0.99	0.00	1.01	0.00	0.26	0.82	0.82	0.74	0.71	0.67
TiO2	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P2O5	1.79	1.00	0.00	0.00	1.55	1.09	0.74	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.57	0.40	0.24	0.00
F	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	1.23	0.27	0.00	0.00	0.52	0.65	0.48	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.22	0.66	0.17	0.00
CO2	28.98	26.66	0.00	0.00	4.65	13.08	44.61	0.00	0.00	0.00	0.00	0.00	0.00	19.19	0.00	0.00	0.00	0.00	0.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
V	16	0	0	0	0	0	0	16	18	0	0	0	0	0	0	0	0	0	0
Sc	99	38	0	0	51	39	31	101	115	123	0	171	0	20	65	65	110	99	119
Cr	26	0	0	0	0	0	0	0	20	7	0	15	0	0	13	13	0	0	0
Ni	25	8	0	0	0	0	24	36	45	54	0	22	0	0	9	9	22	10	18
Co	35	0	0	0	0	17	14	20	34	53	0	54	0	0	18	18	26	0	31
Ba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sr	75	193	211	316	133	163	114	235	301	207	318	197	308	154	254	254	255	206	132
Pb	118	84	55	0	193	107	96	260	248	250	0	168	169	79	199	199	145	124	172
U	158	479	473	513	527	501	295	448	432	661	1114	582	631	313	307	307	335	220	535
Y	72	123	202	266	166	144	114	180	182	196	520	224	371	153	173	173	290	239	171
La	63	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0
Ce	67	0	0	0	0	0	0	0	42	38	0	0	0	0	0	0	0	0	0
Nd	53	0	0	0	0	0	0	28	0	63	0	55	0	0	20	20	0	0	0
Gd	66	0	0	0	35	0	26	75	109	108	0	39	0	0	58	58	0	0	37
Dy	69	0	0	0	64	50	0	98	117	104	0	91	0	0	71	71	62	0	0
Yb	63	23	0	0	135	78	0	35	61	22	0	0	0	0	49	49	0	0	39
Lu	97	0	0	0	98	27	35	80	76	127	0	133	0	0	123	123	89	96	65
Hf	125	0	0	0	55	81	48	159	163	130	0	189	0	0	77	77	27	0	103
Zr	85	207	274	132	262	203	127	273	231	141	374	426	525	230	174	174	282	418	227
Ta	97	0	0	0	82	110	44	180	105	145	0	157	0	0	65	65	118	34	92
Nb	135	274	199	340	304	122	175	203	226	181	160	331	395	232	233	233	209	254	134
il	0.21																		
mt																			
ap	3.47	1.94			3.26	2.17	1.4	1.07							1.18	1.18	0.90	0.45	
caf2	0.88																		
anh	1.56	0.31			0.77	0.87	0.62	0.79							0.34	0.34	0.90	0.22	
nak2c	0.93	0.79	0.22		1.77	0.65	0.62												
cc	67.18	62.93			10.83	31.85	96.62							46.43					
port	23.96	34.03	99.78	100	82.82	64.46		98.15	100	100	100	100	100	53.57	98.49	98.49	98.2	99.33	100
sil	1.39				0.5														
al2c3							0.52												
sic							0.21												
qz	0.46				0.06														

Table 5b: *Calcite and portlandite bearing carbonatite-lava from Alambadi*

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
SiO2	0.79	0.00	0.00	2.79	2.88	2.55	3.18	2.83	0.00	2.86	3.85	2.73	3.00	3.61	4.48	3.66	3.46	3.94	4.13
Al2O3	0.62	0.00	0.00	1.33	1.45	1.41	1.23	1.05	0.00	1.13	1.19	0.80	0.93	0.92	1.26	1.12	1.32	1.23	1.65
FeO	0.30	0.28	0.14	0.93	1.10	1.03	0.90	1.10	0.00	0.73	1.19	0.75	0.37	0.81	1.02	0.81	0.77	0.78	0.61
MgO	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	72.69	97.83	94.85	74.15	65.33	72.42	64.88	78.30	98.19	65.81	84.07	71.79	79.94	76.31	82.76	80.58	79.84	81.40	87.08
Na2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.68	0.76	0.68	0.60	0.44	0.68	0.62	0.80	0.74	0.62	0.87	0.73	0.66	0.69	0.75	0.49	0.53	0.54	0.88
TiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P2O5	1.11	0.49	0.00	0.81	0.77	0.52	0.71	0.38	0.40	1.01	0.91	0.66	0.55	0.97	0.68	0.35	0.62	0.35	0.49
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.79	0.63	0.29	0.00	0.43	0.22	0.29	0.44	0.66	0.42	0.00	0.21	0.23	0.69	0.60	0.00	0.39	0.00	0.00
CO2	22.46	0.00	4.04	19.40	27.60	21.16	28.19	15.08	0.00	27.20	7.91	22.34	14.31	16.00	8.45	12.99	13.07	11.75	5.15
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.01	100.00	100.01	100.00	100.00	100.00	100.00
V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
Sc	68	82	105	55	0	29	0	59	110	36	0	44	18	74	30	25	16	63	0
Cr	0	13	0	0	0	0	0	0	0	0	0	8	0	0	12	0	0	0	0
Ni	0	39	33	0	0	0	8	0	22	22	17	13	11	0	11	0	0	0	0
Co	24	17	0	0	0	0	10	0	26	0	0	0	13	14	21	0	9	0	0
Ba	0	0	0	0	0	0	21	0	0	0	0	0	0	0	26	0	0	0	0
Sr	187	190	172	166	100	125	104	119	255	111	119	186	181	247	100	198	184	196	113
Pb	193	259	212	168	197	48	71	108	145	135	193	0	145	155	197	186	115	114	0
U	427	631	367	360	284	265	308	185	335	369	91	319	309	302	260	397	371	446	232
Y	202	156	235	141	189	120	86	0	290	69	105	173	196	118	192	131	123	199	251
La	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ce	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gd	24	33	88	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0
Dy	0	51	68	0	24	0	57	38	62	24	78	0	67	61	58	68	0	26	0
Yb	105	0	0	40	0	0	0	0	0	25	81	0	0	32	50	76	0	89	0
Lu	60	85	130	0	0	0	0	0	89	0	32	0	0	43	46	30	0	0	0
Hf	98	68	95	22	65	0	28	0	27	0	75	32	42	51	44	82	0	0	0
Zr	196	277	172	145	177	206	144	157	282	182	179	237	125	91	201	213	132	242	100
Ta	93	66	66	26	53	0	46	0	118	44	42	0	68	57	96	87	0	26	0
Nb	165	203	174	80	163	88	132	0	209	56	0	84	199	139	203	189	0	325	167
il																			
mt				0.05	0.10	0.11	0.05	0.11		0.05	0.11	0.05	0.05	0.05	0.11	0.05	0.05	0.05	0.06
ap	2.28	1.07	0.44	1.55	1.52	1.01	1.41	0.7	0.90	1.94	1.93	1.27	1.14	2	1.49	0.71	1.3	0.71	1.05
caf2																			
anh	1.06	0.90			0.52	0.32	0.42	0.76	0.90	0.52		0.32	0.32	0.97	0.88		0.64		
nak2c																			
cc	53.97		10.21	47.12	65.72	51.17	66.95	37.04		64.75	19.83	53.87	35.17	39.22	21.16	32.05	32.27	29.1	12.96
port	41.38	98.03	89.35	47.44	28.14	43.67	27.15	57.72	98.20	29.07	73.33	41.25	59.63	53.54	70.91	62.68	61.27	65.27	80.34
sil	0.95			2.08	2.20	2.23	1.88	1.73		1.73	1.93	1.27	1.46	1.46	2.09	1.79	2.12	1.96	2.66
al2c3																			
sic																			
qz	0.37			1.76	1.78	1.49	2.14	1.94		1.94	2.87	1.96	2.22	2.76	3.36	2.72	2.44	2.89	2.93

Table 6: *Carbonatite lava occurring in quartzite in Perumalmalai, south of Alambadi Main quarry*

	39	40	41	42	43
SiO2	50.60	28.58	19.75	22.64	26.70
Al2O3	2.45	11.12	4.95	4.77	4.06
FeO	0.42	1.29	0.74	0.63	0.63
MgO	0.72	3.90	4.25	3.92	3.44
CaO	1.25	2.97	2.03	2.04	1.59
Na2O	0.58	2.37	3.26	3.14	2.73
K2O	0.38	1.07	1.45	1.52	1.31
TiO2	0.52	0.41	0.00	0.32	0.47
P2O5	0.58	3.15	4.38	4.86	3.59
F	0.61	1.88	2.16	2.17	2.14
Cl	0.31	0.89	1.21	1.26	1.09
S	0.30	2.40	3.57	3.54	3.00
CO2	41.28	39.98	52.25	49.18	49.25
	100	100	100	100	100
V	8	13	16	17	19
Se	30	0	18	14	37
Cr	14	16	26	22	28
Ni	14	6	13	15	22
Co	20	16	25	29	42
Ba	0	47	87	59	44
Sr	132	52	80	58	87
Pb	94	32	59	65	98
Cu	11	7	6	16	15
Zn	25	7	18	21	32
La	27	52	82	80	88
Ce	27	37	27	42	47
Nd	55	37	49	51	55
Eu	51	63	84	84	99
Dy	30	0	18	14	37
Yb	0	34	47	36	46
Lu	63	44	64	58	67
Hf	29	32	57	37	58
Zr	119	87	99	99	139
Ta	46	28	71	51	90
Y	133	61	83	82	128
il	0.71	0.51			0.79
mt		0.05	0.07	0.07	
ap	1.07	5.94	11.59	12.77	8.97
anh	0.41	3.05	6.28	7.37	5.28
nakf	2.75	1.12	15.78		9.1
nakcl		10.16	3.21		4.09
Mgcl2		3.66			
nak2c	1.07			10.46	
cc	2.24	1.12			
al2c3	6.12	27.68	17.11	16.42	13.19
sic	85.36	48.35	45.95	52.91	58.58
qz	0.25				

6. CONCLUSION

During exploration for molybdenite and other sulphide minerals in mine-dump materials in crystalline limestone quarries, the author had a chance to carry out extensive field-traverses in several parts of Tamil Nadu between June 1996 and April 1999. Later on for prospecting and reserve estimation of quartz and feldspar for Trimax Ltd, Chennai, he carried out field work around Saidapuram near Gudur during September 2001. He observed several carbonatite lava flows and silicate perovskite bodies. After exploration of mineralization of Molybdenum deposit occurring in between Uttangarai and Harur at Enchambakkam-Vellayuthampalayam villages [20] nearby carbonatite complex Tiruppattur, Tamil Nadu [13]. Sulphide exploration was proposed in area in the vicinity of Palayam where molybdenite and other sulphides were reported.

The finding of very small bodies of carbonatite-lava, silicate perovskite and basalt carrying notable traces of Mo and related trace elements the area is further recommended for detailed geological, structural mapping and petrologic investigations.

AKNOWLEDGEMENT

The author gratefully thanks to Mr. T. Ragavaiyya, Senior Technician in the Laboratory of Material Sciences, IITM, Chennai-36 for his co-operation during the course of Laboratory investigation.

List Item – 1 Article with 9 pages

List Item - 2 Eight figures

List Item – 3 20 References

List Item - 4 Author's bibliography with photo

REFERENCES

[1] R. Ramasamy *Geochemical studies on carbonatite lava flows in and around Kudangulam area Tamil Nadu India,* IJISSET, v. 3 (2), pp.23-30, Feb. 2017.

[2] R. Ramasamy, *Carbonate-tephrite and bi-model carbonatite lava occurrences in Dharangambadi-Karaikal coast, Tamil Nadu, India,* IJMSET, v. 1. (6) pp. 15-30, 2014.

[3] R. Ramasamy *Carbonatite-lava extrusions along ring fractures, south of Sivamalai alkaline complex, Tamil Nadu, India,* IJISSET, 2017 (in press)

[4] R. Ramasamy, *Silicate perovskite (Si-Fe-Nb-Ca-Ti) lava flows in Tamil Nadu,* IJISSET, v. 2 (11), pp.8-15, 2016.

[5] C.G.B. Dubois, J. Furst, N.J. Guest and D.J. Jennings, *Fresh Natro-carbonatite lava from Oldoinyo L'engai,* Nature, v.197, pp445-446,02 Feb 1963.

[6] S.V. Sokolov, *Portlandite in rocks of carbonatite massifs, Geochemistry International,* v. 52 (8) pp.698-701, August, 2014.

[7] N. M. Podgornykh, *Inclusions in apatite from carbonatite complexes of Eastern Sayan and their petrological significance,* in *Petrology of Lithosphere and Ore Potential* (Leningrad, 1981)

[8] I. P. Solovova, A. V. Girnis, A. V. Guzhova, and V. B. Naumov, *Magmatic salt inclusions in the minerals of alkaline basalts in the Eastern Pamirs,* Geokhimiya, No. 1, pp.68–77 (1992).

[9] I. P. Solovova, I. D. Ryabchikov, L. N. Kogarko, and N. N. Kononkova, *Inclusions in minerals of the Palaborwa carbonatite complex, South Africa,* Geochem. Int. **36**(5), pp.377–388 1998.

[10] Ramachandran Ramasamy Carbonatite bombs, lapillus, pisolites and ashes in semi-unconsolidated conglomerate of Early Pleistocene from Thiruvalan- gadu Tamil Nadu, India Int. Journal of Engineering Research and Applications vol. 4, Issue 8, pp. 112-119 August 2014.

[11] A. Rittmann, *Stable Mineral Assemblages of Igneous Rocks,* Springer-Verlag, Berlin, 264p, 1973.

[12] M. J. Le Bas, R.W. Le Maitre, A. Steckeisen and B. Zanettin, *A chemical classification of volcanic rocks based on the Total Alkali-Silica Diagram*, Journal of Petrology, v. 27, pp. 745-50, 1986.

[13] S. Saravanan, and R. Ramasamy, *Geochemistry and petrogenesis of shonkinite and associated alkaline rocks of Tiruppattur carbonatite complex, Tamil Nadu,* Journal of the Geological Society of India, v. 46, pp. 235-243, 1995.

[14] R. Ramasamy, *Basaltic-lava extrusions between the years 1996 and 2004 in some parts of Tamil Nadu, India* , ijisset, v, 3 (9) pp. 17-23, 2017.

[15] P.J. Wyllie and O.F. Tuttle, The system CaO-CO_2–H_2O and the origin of carbonatites. Jour. Petrology, v.1, pp.1-46. 1960.

[16] N.C. Caciagli, and C.E. Manning, *The solubility of calcite in water at 6–16 kbar and 500–800 °C.* Contributions to Mineralogy and Petrology, v. 146 pp 275-285 2003

[17] R.C. Newton and C.E. Manning, *Experimental determination of calcite solubility in H2O-NaCl solutions at deep crust/upper mantle pressures and temperatures: Implications for metasomatic processes in shear zones.* American Mineralogist, v.87, pp. 1401–1409, 2002.

[18] C. Lazar, CHI Zhang, C.E. Manning and B. O. Mysen, *Redox effects on calcite-portlandite fluid equilibria at forearc conditions: carbon mobility, methanogenesis, and reduction melting of calcite,* American Mineralogist, v. 99. pp. 1604-1615, 2014

[19] D. Weidendorfer, Max. W. Schmidt, and H.B. Mattsion *A Common origin of carbonatite magmas* Ceology v. 45 (6) pp. 507-510, 2017.

[20] https://mnes.gov.in/writereaddata/UploadFile/GSI.pdf

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