ISSN 2455-4863 (Online) **www.ijisset.org** *Volume: 5 Issue: 9 | 2019*

Carbonatite-tuff in Sattangulam and other parts of Tamil Nadu, India

R. Ramasamy

Former Deputy Director, Department of Geology and Mining, Chennai, 600 0032; 6/90, Pavanar, Street, Thirty Feet Road, Polichalur, Chennai, 600 074.

Abstract: *A fine-grained pale yellowish to white coloured massive compact calcium carbonate tuff intercalated with coeval air flown lapillus, pisolites and Mio-Pliocene shells. It is found in southern part of Tamil Nadu. It is controlled by WNW-ESE lineaments similar to emplacement of sovite in Kudangulam. An occurrence of carbonatitic lava materials of grey and pink lapillus, pisolites and ash in conglomeratic calcareous gritty sandstone of Early Pleistocene Period in Thiruvalangadu region might have been indicate latest bi-model carbonatitic volcanism earlier grey followed by pink ones. Lineament passes through middle of tuff for a quite long distance. Curvilinear lineaments indicate features of cone-sheets or cauldron subsidence. The tuff is silica undersaturated and alkali enriched. Positive linear variations are seen between Al – Si; Y – Sr; Pb- U; Nb-Zr; niobate-baddeleyite and anhydrite against and apatite. Negative correlation between HREE vs LREE and (Na+K) vs Si ions show enrichment of HREE and Si respectively with relative higher dissolution of LREE and (Na+K) from the tuff. Fluidization of gaseous constituents emanated from volcanic activities acted on host rocks of granite gneiss transform into kaolin with rounded transparent quartz near Tisaiyanvilai and other places. The wide-spread carbonatite tuff activity might have been triggered during NNE movement of Indian Plate where feeder dykes at varying depths remained stable at depth while upper crust moved towards Himalayan Region during Late Cenozoic Period.*

Keywords: Carbonatite-tuff; Silica under saturated; Ash-flow tuff; Indian Pate movement.

1. INDRODUCTION

Tufaceous rocks described by some earlier geologists [1, 2, 3, 4, 5, 6] are restudied and reported as weathered carbonatite ash flow tuff exposed in southern parts of Tamil Nadu. 0Magmatic origin for carbonatite was widely accepted only after eruption of natrocarbonatite [7] from Eastern Tanzania. After, this eruption many tuffs and limestone are proved and included in the list of carbonatites [8]. Though, samples of carbonatitic lapillus are collected from Kudangulam during geological studies in 1983 itself carbonatitic volcanic activities are recognized only after finding carbonatitic lapillus, pisolites and ashes all together in a conglomeratic calcareous gritty sandstone of Early Pleistocene Period from Thiruvalangadu region spreading over 90 km^2 [9]. Both grey and pink coloured lapillus, pisolites and ashes are found together in the above sandstone, grey coloured lapillus, pisolites and ashes appear to be just earlier than pink ones [9]. Similar features are manifested at Dharangambadi, Kudangulam, Sattangulam, and Podupatti [10, 11, 12]. In places, Carbonate-tephrite [13] and soda-trachyte [14] and sovite [15] are seen in this area. At some places host rocks are metasomatised and fluidized [16] and clay deposits with transparent quartz are formed as surface deposits. At Vijayapathi, near Kudangulam 10m thick kaolin deposit is found in a well section. Clay deposit of varying thickness is found at Idinthakarai and Tisaiyanvilai. A reddish brown compact clay deposit is found at Surankudi. About 8 km NE of Maravaperugudi 3 patches of carbonatite tuff are associated with fluidized reddish brown to white coloured clay covering several hundred km^2. Though they are surface deposits they account for several million tons easy to mine and utilize for industries.

2. FIRLD STUDIES

Several field traverses were made since 1982 to study carbonatite tuff included with lapillus and pisolites. Initially fresh carbonatitic volcanic lapillus 6x5x3 cm and pisolites 2x1.5x1.5 cm found as coeval materials included in the tuff are studied [9, 11, 12]. Then host rock of tuff is studied. The physical properties and nature of weathering pattern are distinctly varied from any ordinary kankar. The tuff exhibits solution effect and precipitation of chalcedony in weak planes and in vugs. Dark films and dark-black ash materials are seen in tuff. The charnockitic wall rock of the tuff shows contact metamorphic effect from 5 to 10 mm width more development amphibole and biotite and it distinctly vary from the original host rock (Fig. 1). The rock exhibits flow lines for its ascent (Fig. 1).

Fig 1 a. partially kaolinized granite gneiss

b. carbonatite tuff

c. carbonatite tuff with shards & dark patches and pisolites

d. wall rock of ash flow tuff showing contact-metamorphic effect

e. wall rock of ash flow tuff showing contact-metamorphic effect

f. flow lines present in ash flow tuff

g. fine-grained texture of a lapillus

h. globular pisolites within lapillus

The broken piece of lapillus is very fine-grained and it rarely shows early formed globular (1 cm diagram) pisolites within the lapillus (Fig. 1). At some portions incipient development of linear and circular porphyries calcite are seen. Lapillus enclosing pisolites indicates volcanic nature (Fig. 1). Fresh compact dark unaltered fragments of <20 x 15µm of varying sizes from square to rectangular cross sections are found (Fig. 1) in some tuffs. It distinctly varies from the rock formed by meteoric circulation with development of cavernous structure forming good aquifers channels along peripheral portions of teri sand dunes. The rock is locally called as mankottaiparai for its easiness to mine, dress for construction work.

Fig: 2- Simplified map of occurrence of lapillus, pisolites and ash bimodal volcanic materials in calcareous gritty sandstone near Thiruvalangadu village near Chennai.

Fig: 3 A curvilinear trend of ash flow tuff from Maravaperugudi, Surengudi, Muthulapuram, Duraiyur, Podupatti, Kadambur, Kayattar, Uthumalai, Surendai, Sendamaram and Sankarankoil is shown. The belt shows a basin structure plunging steeply towards NEN. The longest tuff belt using radius and steep

inward dipping with their tan Θ [17, 18], it is known that the tuff might have been derived from a fracture at a maximum depth of 425 km.

Fig: 4 Carbonatite-tuff trends WNW-ESE direction passing through Tsaiyanvilai, Ittamozli, Sattangulam, Nazareth, Pannamparai Meyygna-puram and southernmost belt trends WNW-ESE includes Kudangulam, Radhapuram, Thiruvambalapuram, Kasthurirengapuram and Samugarengapuram.

ISSN 2455-4863 (Online) **www.ijisset.org** *Volume: 5 Issue: 9 | 2019*

Fig:-5 Ash flow patches are respectively seen in a) Kudangulam (derived from 18km depth]17, 18] , b) Sattangulam (derived from 10km depth), and c) Tisaiyanvilai, d) Hogenekkal (Chinnru valley-Hogenekkal- Anchetty 15 km distance in arc shaped (derived from 10km depth), at foot hill of Malapuram (28 km SW of Madurai) ash tuff are seen. In limestone mine of Walaiyar (h) both clay tuff and crystalline limestone is found in some places. Black coloured thin films and patches are seen at boundaries of calcite grains in the crystalline limestone of Pandalgudi, Eppodumvendran, Podupatti, and Singikulam. Similar dark coloured thin films are found in Uthumalai tuff on broken surfaces. Graphite is found as inclusions in the crystalline limestone at Valliyur.

Fig: 6. Carbonatite tuff associated with fluidized reddish brown and white clay near Surankudi and 8 km NE of Maravaperugudi along coastal tracts.

3. PETROGRAPHY

All particles present in the tuff are fluidized and their grains are rounded elliptical ovoid or flat. Tuff is soft and porous and easily subjected to chemical weathering and leaching. It is a very fine-grained rock. SEM images indicate mean size of particle is around 1 µm (Fig. 7). Many aggregates not exceed over 5 µm are found on glassy carbonate matrix. Air flown particles deposited within limited distance controlled by lineaments. Lapillus and pisolites are highly flattened in the ratios of (10:4:1) due to low viscosity and high temperature [19] in Thiruvalangadu and Dharangambadi coast but in Kudangulam and in Sattangulam they are more or less globular or ovoid in form. Texture of carbonatitic pyroclastic fragments is very homogeneous fine-grained compact massive and holocrystalline nature. However, skeletal and telescopic growths of calcite grains are rarely developed. Black coloured lapillus is abundantly seen in ash flow tuffs occurring 2 km NE of Sattangulam along WNW-SES lineament which is parallel to the lineament controlled by emplacement of sovite in Kudangulam [15] Sovite occurring in Kudangulam is composed of very large grains of calcite, apatite and phlogopite booklets. Along coastal tracts some older Mio-Pliocene gastropods and lamellibranches shells are cemented with tuff. Some broken pieces also exhibit such fossils. But many of the tuffs are free from either lapillus or pisolites or shells. Concretions with reddish brown rims are found on some pisolites aggregates on peripheral portions of rims.

4. GEOCHEMISTRY

Rittmann's [20] norm calculated for EDAX spot analyses (Fig. 7 and Table 1) show the tuff is extremely silica undersaturated with alkali enriched constituents of nepheline, kalsilite, sodasilite and potasilite components. These constituents remained in tuff indicate that the original rock might have been more enriched with such alkaline constituents and they might have been leached out from it during course of time. Therefore, at present calcium carbonate is enriched. Some analyses show presence of portlandite in significant weight percent. In addition to this calcium silicate perovskite is present from 19 to 64 (wt. %). The presence of calcium silicate perovskite indicates that volcanic melt appears to be derived from deep mantle source greater depth over 2000 km depth.

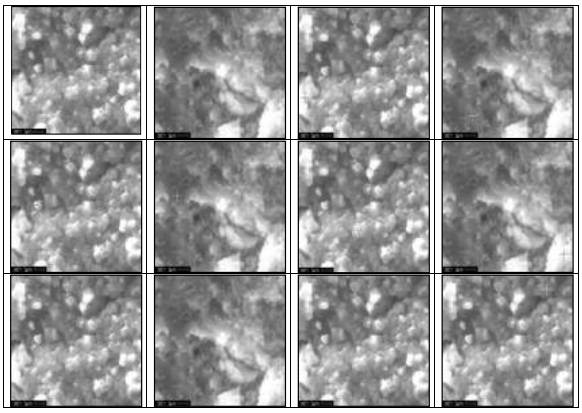

Fig:-7. EDAX spot analyses listed in the Table 1. represents sequential order of spot analyses.

Notable enrichment of normative kalsilite, nepheline, sodasilite and potasilite are found. Tuffs with fluidized clay are closely associated with crystalline limestone in Walaiyar limestone mine and Kudangulam Idinthakarai, Vijayapathi, Tisaiyanvilai and Muttam. Tuff is found along southern and northern flanks of Large calcite phenocryst 20x5 mm in fine-grained calcite matrix is seen in porphyritic carbonatite tuff collected in Podupatti, Eppodumvendran and Singikulam. Some samples are drastically enriched in CaO% with significant enrichment of Calcium silicate perovskite. These features indicate that original material is developed deep-seated lower mantle source at a depth of over 2000 km [21].

Table 1 EDAX Chemical compositions of carbonatite-tuff sample and their trace element contents numbers increases from left to right same image on both sides.

Uttumalai	Carbonatite tuff										
SiO2	4.66	3.85	4.33	4.55	3.86	4.79	4.56	0.60	1.08	0.63	1.41	0.77
Al2O3	1.81	1.53	1.81	1.70	1.58	1.49	1.47	0.00	0.54	0.37	0.80	0.00
FeO	0.42	0.40	0.37	0.34	0.24	0.42	0.44	0.00	0.24	0.26	0.11	0.13
MgO	1.75	1.39	1.89	1.79	1.35	1.27	1.38	1.36	1.40	1.44	2.60	0.66
CaO	38.26	29.38	24.98	28.80	38.00	36.89	34.26	56.23	54.02	45.57	38.43	73.85
Na2O	0.54	0.75	0.84	0.74	0.52	0.43	0.40	0.00	0.00	0.10	0.42	0.00
K2O	0.67	0.57	0.49	0.59	0.61	0.74	0.35	0.30	0.62	0.66	0.49	0.76
TiO2	0.13	0.04	0.15	0.11	0.05	0.25	0.00	0.00	0.00	0.00	0.10	0.00
P2O5	1.34	1.19	1.15	1.21	1.34	1.31	0.77	0.44	1.31	0.94	1.11	0.99
SO3	1.34	1.20	1.21	1.07	1.27	1.34	0.67	0.27	1.10	0.78	1.02	0.94
CO2	41.75	51.85	56.96	52.73	46.63	43.34	48.82	30.47	27.09	38.60	44.99	9.21
F	0.08	0.52	0.89	0.43	0.30	0.10	0.31	0.00	0.00	0.00	0.14	0.00
Cl	0.44	0.36	0.32	0.39	0.39	0.41	0.12	0.00	0.33	0.28	0.31	0.35
Sc	0.51	0.34	0.41	0.43	0.59	0.54	0.00	0.00	0.50	0.82	0.44	0.74
Cr2O3	0.18	0.22	0.22	0.20	0.14	0.19	0.00	0.00	0.37	0.24	0.14	0.25
CoO	0.15	0.18	0.20	0.17	0.10	0.32	0.00	0.00	0.26	0.29	0.16	0.21
NiO	0.00	0.22	0.10	0.22	0.12	0.08	0.15	0.00	0.17	0.19	0.14	0.00
Rb2O	0.65	0.41	0.13	0.29	0.20	0.47	0.29	0.94	0.87	0.94	0.57	1.01
SrO	0.99	0.87	0.65	0.61	0.30	0.57	1.23	1.61	1.33	1.56	1.34	2.51
Y2O3	1.37	1.14	0.60	0.91	0.51	1.09	1.15	1.79	2.23	1.60	1.27	1.28
ZrO2	1.58	1.67	0.90	1.09	0.58	1.06	1.23	2.39	2.70	2.28	2.57	3.62
Nb2O5	1.38	1.94	1.42	1.63	1.32	2.92	2.38	3.61	3.84	2.47	1.43	2.74
	Rittmann's Norm											
zr												0.24
bad	1.08	1.4	0.83	0.85	0.4	0.72	1.69	1.58	2.28	1.54	1.9	2.51
nbt	0.79	0.93	1.05	0.91	0.68	1.56	1.01	1.52	1.94	0.99	0.71	1.19
mt	0.28	0.33	0.08	0.07	0.06	0.06	0.06		0.07			
ap	2.89	3	3.23	2.93	2.88	2.67	1.63	0.87	3.53	1.92	2.56	2.21
anh	1.93	2	2.25	1.69	1.81	1.89	0.9	0.33	1.94	1.1	1.55	1.43
sif4	0.28	2.27	4.43	1.89	1.13	0.33	1.13				0.54	
sicl4	1.25	0.87	0.83	0.91	0.79	0.83	0.23		0.76	0.55	0.65	0.78
fesccry	1.25	2.13	1.05	1.04	0.79	0.56	0.56		2.21	1.65	1.19	1.55
feconi	0.23	0.67	0.6	0.65	0.34	0.56	0.23		0.69	0.77	0.48	0.36
cc	83.51	82.8	81.5	85.55	88.59	88.05	90.71	75.26	85.2	89.67	88	24.96
kal	2.89											
nep	2.89											
ks		1.2	1.13	1.17	1.07	1.61	0.79	0.87	1.38	1.59	1.19	1.43
ns		2.4	3	2.34	1.47	1.17	1.07			0.22	1.25	
an	0.74											
pvs								18.71				63.58

The bi-components of niobate against baddeleyite show positive linear variation with scattering due to insufficient silica to form zircon. Anhydrite against apatite show linear enrichment at early stages of crystallization but at late stages heterogenic enrichment of these constituents either due to rapid escape of gaseous constituents like Cl, F, P_2O_5 , SO_3 and CO_2 scattered distribution occurs. The enrichment of reactive chlorides and fluorides, nepheline, kalsilites, sodasilites and potasilites indicate alkali rich environment prevailed during the course precipitation of tuff. SiF_4 dominates at late stages. Carbonate contents increase at late stages showing dissolution of tuff leading to enrichment over 80%. Al vs Si; Y vs Sr; Pb vs U, Al vs Si and Nb vs Zr show positive linear variations (Fig.8). On other hand HREE vs LREE and (Na+K) vs Si exhibit negative correlations due to relative to high dissolution of LREE and (Na+K) respectively HREE and (Na+K) suggesting that the present tuff is residuum of original alkali bearing carbonatite lava source (Fig. 7).

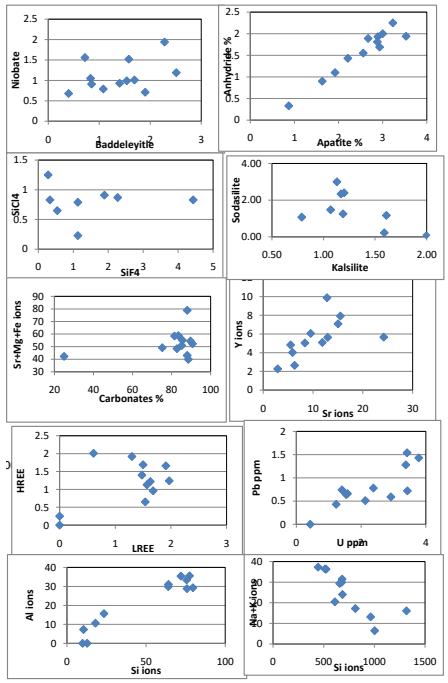

Fig. 8: Bi-component variation of major and trace elements in carbonatitic ash flow tuff.

5. CONCLUSIONS

Physical properties and chemical compositions of ash flow tuff derived from deep mantle source included with globular ovoid or flat air flown carbonatitic lava fragments restricted to certain lineaments along which wide spread volcanic activities in Tamil Nadu are held. Hot gaseous constituents escaped from volcanic pipes fluidized host rocks of granite gneisses into kaolin and granular transparent quartz. The ash flow tuff in large quantity occurs as $CaCO_3$ is useful for cement and chemical industries.

List Item –Article. 1-8

List Item Figures 1-8

List Item –Table 1. EDAX Analyses & norms

List Item –References 21

ACKNOWLEDGEMENT

The author expresses his sincere thanks for co-operation of Thiru. T. Ragavaiyya during EDAX analyses of riebeckite samples in the Department of Material Sciences and Metallurgical Engineering, Indian Institute of Technology, IITM, Chennai, 600 036.

REFERENCES

[1] N.K.N. Aiyengar, Minerals of Madras, Dept. Industries and Commerce, Chennai-32, pp.1-200, 1964.

[2] S. Narayanaswamy, The geology and mineral resources of the Sankarankovil taluk and Uttumalai Zamindari, Tirunelveli District, Madras Presidency, Unpub. GSI P.R for F.S. 1943-44.

[3] S. Narayanaswamy, The geology and mineral resources of the Tiruchendur and southern and eastern portions of the Nanguneri taluk, Tir5nelveli District, Unpub. GSI. P.R. for the F.S. 1946-1947.

[4] P.K. Muralidharan *Geological R.and Geomorpholohical mapping of Quaternary Sediments around Thiruchendur area, V.O.C District and Kanyakumari area, Kanyakumari District, Tamil Nadu,* Geol. Surv. India Prog. Rept. 1986- 87

[5] S.V. Vaikundam, C. Ramalingam, and K. Balasubramaniam, *A Report on the detailed Investigation for shell limestone in Kudangulam village, Radhapuram Taluka, Thirunelveli District, Tamil Nadu,* Department of Geology and Mining, 1983

[6] E.W. Verdenburg *Considerations regarding the age of Cuddalore Series*, Geol. Surv. India, Rec. 36, pp. 321-323, 1908

[7] J. B. Dawson, Sodium carbonate lavas from Oldoiniyo Lengai,Tanyika v. 195, pp1075-1076, 1962.

[8] O.F. Tuttle and J, Gittins,. Edrs Carbonatites,1966. O.F. Tuttle and J. Gittins *Introduction*- in pp. xi-xiii, J. Wiley, New York, 1966

[9] R. Ramasamy, *Carbonatite bombs, lapillus, pisolites and ashes in semi-unconsolidated conglomerate of Early Pleistocene from Thiruvalangadu, Tamil Nadu, India,* IJERA, v. 4(8) pp.112-19, 2014.

[10] R. Ramasamy, *Carbonate-tephrite and bi-bi model carbonatite-lava occurrences in the Dharangambadi-Karaikal Coast, Tamil Nadu, India,* IJMSET, v. 1 (6), pp.15-29, 2014.

[11] R. Ramasamy, *Evidences of Neocene carbonatitic volcano-tectonic deformations in Kudangulam area, Cape Comorin, Tamil Nadu,* Tamil Civilization, v. 14-18, pp.167-179, 1996-2000

[12] 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..

[13] R. Ramasamy *Occurrences of olivine-tephrite and carbonate-tephrite in Kudangulam area, near Cape Comorin, Tamil Nadu, India,* J. Geol. Soc. of India, v 45 (3) pp.331-333, 1995

[14] R. Ramasamy *Occurrences of soda-trachyte near Kudangulam village, Tamil Nadu, South India,* Curr, Sci. v 61, pp. 401-402, 1991.

[15] R. Ramasamy, *Carbonatite dykes from Kudangulam area, near Cape Comorin, Tamil Nadu,* J. Geol. Soc. of India, v. 48 (2), pp. 221-226, 1996.

[16] R. Ramasamy, effects of metasomatism on the coumtry rocks around the Carbonates of Kudangulam area m Tamil Nadu, Journ. Geol. Soc. India, v. 46, Aug. pp.117-123, 1995

[17] H. von Eckermann , The genesis of Alno Alkaline Rocks, 18th Session Great Brittan. . v. 111, pp. 94-101.

[18] E. Wm. Heinrich, The Geology of Carbonatites, Rand Mc Nally & Company, Chigaco, pp. pp.555 + Xlv, 1966

[19] J. Gittins and O. F. Tuttle The System CaF_2-$Ca(OH)_2$-$CaCO_3$ Am. J. Sci. v. 262, pp/ 66-75, 1964.

[20] A. Rittmann, *Stable mineral assemblages of gneous rocks,* Springer Verlag, Berlin, 262p 1973.

[21] *Calcium Silicate Perovskite- GKToday https://WWW.gktoday.in/gk/calcium-silicate-perovskite/ April 24 2018*

AUTHORS' BIOGRAPHIES

Dr. R. Ramasamy, Ph.D. Univ. Madras 1974 and P.D.F. (MSU 1977-80), served as Petrologist Dept. of Geol & Min. Proj. Advisor, C.E & OE, IITM.