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

ISSN 2455-4863 (Online) www.ijisset.org *Volume: 3 Issue: 9 | September 2017*

Basaltic-Lava Extrusions between the Years 1996 and 2004 in Some Parts of Tamil Nadu, India

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Abstract: *Geochemistry and petrography of rock-melt extrusions between the years 1996 and 2004 in Sirukinaru* (10°52'19"N: 77°31'15"E) *(Dharapuram), Abishekapatti* (8°45'23"N: 77°37'06"E) *Parapadi* (8°37'24"N: 77°43'52"E), *Thiruppanikkarisalgulam* (8°40'42N: 77°40'50"E) *(Thirunelveli), Vadamam bakkam* (13°06'10"N: 79°39'36"E), *Nagavedu* (13°04'04"N: 79°40'13"E) *(Arakkonam), Anikkulam* (8°58'38"N: 77°25'10"E) *(Surendai) and Top-slip* (10°28'07"N: 76°50'37"E) *(Pollachi) reveal their basaltic nature. Pele's hair, shards, lava-tubes,, flows, cow-dung like spreading of lava materials, clinging of lava on tree branches which were burnt by extensive heat liberated. Beads (1-5 mm) pierced through dolerite floats on granite gneisses in Vadamambakkam were also seen with aureoles of white rim of ash. The volume of eruptive or effusive materials was frequently < 1m³. The chemical compositions of these volcanic materials were subjected to extensive degassing of volatiles and vary from alkali-basaltic, tholeiitic and andesite types or basanite to phonotephrite. The study reveals that existence of micro-volcanic activities is possible. In this paper it is documented that rootless micro volcanic vents varying between < 2cm and >15cm exist on ground surface emitting basalt < 1 m³. The degree of viscosity changes might have been related to chemical variations of basaltic melts derived from deep-seated mantle source. The chemical variation is similar to ascending basaltic melts in different tectonic settings of diverging plate margins, convergent plate margins and Intra-plate volcanism by their degassing volatiles. The extreme chemical variation within 1mm² in EDAX show wide viscosity changes in melt. The different types of basalts might have been due to viscosity changes by extensive degassing of gas bubbles, timing and styles of extrusion during / pre-eruptive condition.*

Keywords: *Fulgurites, Rock-melt extrusions, Tamil Nadu, Lava-tubes, Micro-volcanic flows, Volatiles degassing.*

1. INTRODUCTION

During the course of volcanic activity several thousands of m³ are erupted or flown out from crater. In this paper, volcanic activities less than 1m³ were reported from several parts of Tamil Nadu as micro-volcanism [1]. The eruptive material was previously considered as fulgurites [2-7] formed by impact of lightening strike on the ground surface. The impact of such a strike can produce temperature of 100000°K and 10Gpa pressure within a few seconds sufficient to melt surface material [3-7]. The corrosion and burning of electrical post nearby in Sirukinaru village (10°52'19"N: 77°31'15"E), 15 km north of Dharapuram. Sinking of an electrical post 2-3m depth in Abishekapatti (8°45'23"N: 77°39'06"E) 10km west of Thirunelveli Town [4, 5] and 1m depth in Nagavedu village (13°04'04"N: 79°40'13"E) 10km south of Arakkonam Town Some geologists thought that such activities were due to discharge of electrical power from high-tension power-lines during the course of heavy rainfall [3-7]. After that no attention was paid for subsequent extrusions in several parts of Tamil Nadu (Fig. 1). These rocks were characterized by volcanic texture pitted with many cavities having glossy appearance inside. More detailed petrography and geochemical studies reveal their volcanic nature.

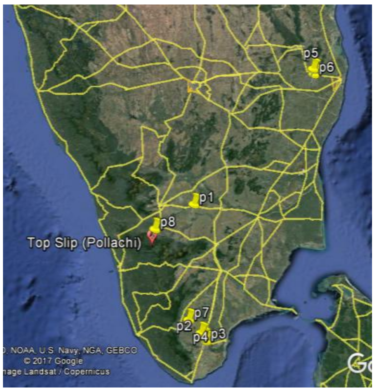

Fig 1: *shows sites of melt extrusions between 1996 and 2004 of p1-p8 numbered according to year-wise.*

2. FIELD STUDIES

On 24th June 1996, at about 21.00 hrs, a thunder-like sound was heard, followed by continuous out-flow and spray of molten rocky material for a few seconds from two small holes of 3 and 2cm dimension at bottom of an electrical-post situated 30cm east of the post situated about 1km west of Sirukinaru village and 12km north of Dharapuram Town (Fig. 2). The dimension of the holes drastically reduced from 3cm at the ground surface from 1.5 to 1cm at 50cm depth and appeared to be rootless at 1 to 2 m depth. The extensive heat liberated at that moment charred the bottom of the post for a volume of 10x10x3 cm^3 in Sirukinaru village (10°52'19"N: 77°31'15"E). About 100 to 300mm diameter low-viscous cow-dung-like extruded molten materials of varying thickness from < 5mm to >20mm spread for distance of 20 to 30m from orifice of small holes and appeared to be rootless at 1m depth. Tree branches within the distance were burnt and some of molten materials of dimension of maximum size of 30x20x10cm^3 cling on branches. Flow of such material was seen around the holes. Pele's hair, obsidian, shards and porphyritic obsidian carrying phenocrysts of feldspar and quartz with lava-flow flow and vesicular characteristics were seen. Inside portions of tubes, holes, gas-bubbles and vesicles formed by escape of gases were smooth, dark and glossy as in slag.

Fig 2: *shows field evidences on the volcanic nature of extruded materials in Sirukinaru village. Sample of about 5cm thick lava with tubes, vesicles and holes were formed by escape of volatiles during flow over soil. Bottom portion of lava flow had chilled margin with sharp contact. Soil materials were burnt by heat of lava flow. Similar features were found in other parts of Tamil Nadu with varying vent sizes of maximum 15cm.*

The outer surface of the molten material appeared to be rugged, jagged and rough furnace clinker. Pits, vesicles and patches of varying dimensions were seen (Fig.3). Spray of beads and glassy globules of <1 to >10mm were found 20 to 50m from orifice. In Vadamambakkam (13°06'10"N: 79°39'36"E) 4 km NNW of Arakkonam Town, the beads were so hot and speedy, pierce through some of dolerite floats strewn on the ground surface passed sideward to other end. Large tube-like flows were seen at about 1km (10°28'07"N: 76°50'37"E) east of Top-slip (Pollachi). Very insignificant volume of materials was extruded in the village of Parapadi (8°37'24"N: 77°43'52"E) (Nanguneri) and Anikulam (8°58'38"N: 77°25'10"E) (Surendai). In top-slip large tubes 15 cm diameter and length of 30cm was found. Inner portion of the tube was very smooth and glossy in appearance with rugged outer surfaces. It was found at root of tree trunk and it was completely burnt. Almost all the sites of extrusions were related with deep-fault system [8]. Flow of obsidian was seen around the orifice. Though some images of fulgurites in web-sites glassy beads, and shards of obsidian were included [9]. The origin of tube like material surrounded by sandy grains described as fulgurites deserves for further investigation. Large outcrops of carbonate bearing fulgurites reported from Malta Island [10, 11] and tubular ironstone in sandstone formation in Blue Mountain, Australia [12] need to be investigated. The petrography and geochemical studies currently investigated shed new-light on the rock.

3. PETROGRAPHIC INVESTIGATION

Petrography is a powerful tool to characterize nature of any sample. The rock had very fine-grained texture. It was largely composed of obsidian. It exhibits vesicular texture with pits, tubes and vesicles. Megascopic microscopic and scanning electron microscopic studies were made on these extrusive rocks during the years between 1996 and 2004 from different parts of Tamil Nadu [1]. Obsidian without any inclusions of feldsic minerals were fine-grained and show perlitic cracks amidst glassy matrix. It shows very smooth conchoidal fracture with sharp edges showing curvilinear pattern among fine-grained matrix. Euhedral phenocrysts of quartz and feldspar (5x3mm) were found in porphyritic obsidian. Peripheral portions of some xenocryst of quartz were corroded by reaction with fine-grained matrix. Tensional cracks were developed perpendicular to the length of some feldspar grains and glassy matrix impregnated along the cracks. Columnar micro-texture produced by rapid cooling and flow-folding of one layer over other was seen.

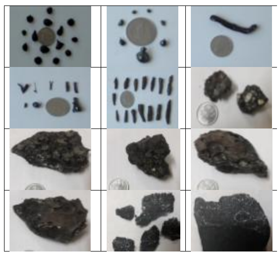

Fig 3: *Some samples of extruded beads, coalescing beads, tailed beads, pele's hair, obsidian, porphyritic obsidian with euhedral phenocrysts and xenoliths in a fine-grained glassy matrix, clinker with tubes and vesicles inside glossy were seen. The last picture was a dolerite float through which a very hot 5mm diameter glassy-bead passing out from top to sideward was seen. Many such dolerite floats were affected by such impacts of globular beads were seen at Vadamambakkam 4 km NNW of Arakkonam Town. The holes were charred out with white rim of ash at inner periphery of holes.*

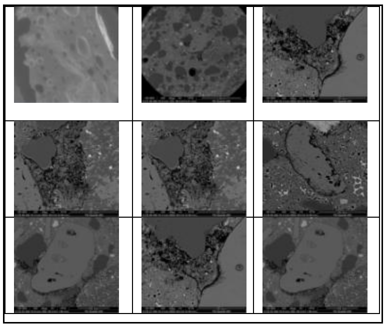

Fig 4a: *Scanning Electron Microscopic images of samples from Sirukinaru village 40x*

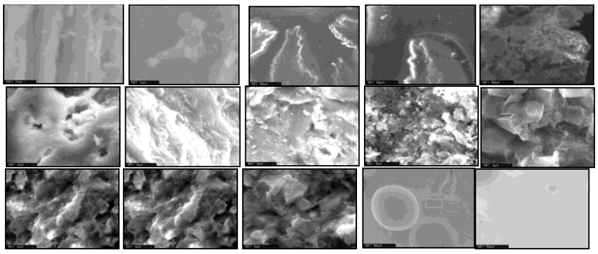

Fig 4b: *Scanning Electron Microscopic images of samples from Sirukinaru village (Top two rows) and Vadamambakkam village (Third row) were shown.*

Very large glossy tubes of dimension varying from 10 to 15 cm were seen at 1km SE of Top-slip. Both columnar structure, embryonic skeletal crystal, formation of plate like crystals during flow-movement and glassy globules were seen in these samples.

Petrography of samples collected from other places also appeared to be very similar. Under higher magnification, size, shape and mutual relationship (texture) of mineral grains and their sequential crystallization and chemical compositional variations might be correlated by using such images. Presence of parallel series of columns of sizes >100x2μm showed rapid cooling of melt. A globular melt inclusion (1000x500μm) carries several plate-lets of <0.5 μm thick embryonic plate-like skeletal crystals of size varying from 600x200μm to 400 x100μm were seen inside. Around these skeletal-crystals peripheral rim of glass and 30% volume concentration of gaseous constituents were seen. Such melt inclusions are primary and do not have any leakage and representing actual volume percent of gaseous constituents [13]. Though water vapour may exceed over 90% of total volume of gases, CO_2 was the next enriched matter [13, 14] followed by P_2O_5, SO_3, F and Cl. The concentration and fugacity of these volatiles widely vary depending up on local variation in viscosity, temperature, pressure and degree of degassing at particular site of EDAX analysis within $1mm^2$. Linear and irregular gas cavities 100 to 50x2μm were seen. The size of globular beads varied between <1 and >10 mm. Two or three coalesced beads and tailed beads were commonly seen. Further shallow-pits, vesicles and tubes of varying sizes and shapes represented escape of volatile constituents. Water was unable to determine by EDAX analyses. However, size and shape of gas cavities play critical role on the viscosity of the melt and styles of extrusion. Accordingly roundness and smoothness of cavities form due to the style of eruption of low-viscous lava. The volume percent of such gas cavities varied from 20 to 60%. Vitrophyric texture was seen in thin section under polarizing microscope. All these images showed basaltic characteristics. Rittman's norm [15] indicated that they had almost equal proportions of mafic and feldsic minerals. The plagioclase varied from andesine to bytownite. Sanidine was low in volume proportions. Some pyroxene were composed with acmite ions. Nepheline ions present in silica undersaturated melt. Some other sites presence of significant amount of cordierite and excessive alumina and quartz indicated that they were subjected to extensive quantities degassing of volatiles. The author assumed that different degree of escape of volatiles filled bubbles from same basaltic melt was controlled and caused for such wide chemical variations among basalts. The geochemical studies further support the view.

4. GEOCHEMICAL STUDIES

Wet-gravimetric chemical analyses were made for extrusive samples collected at different places. The chemical compositions were normalized to sum of 100% by omitting H_2O and loss on ignization (L.O.I) which includes combined water, CO_2 and other volatiles. The composition represents only, residual concentrations of refractory components of the sample. Table 1 and Fig.5 represent chemical variations of these samples collected from Sirukinaru, Abishekapatti, Thiruppanikkarisalgulam, Vadamamambakkam and Nagavedu. Rittmann's norm was calculated [15]. Though most of rocks were quartz normative, some were enriched with olivine and some others were extremely silica deficient and nepheline normative. Both clinopyroxene and hypersthene were present. The presence of high alumina leads to formation of cordierite and sillimanite. Clino-pyroxene was composed of some alkali ions. K ions were dominant over Na ions. The values of $\sigma = (Na2O+K2O)^2 / (SiO2-43)$ and $\tau = (Al_2O_3-Na_2O)/TiO_2$ are discriminate factors to classify alkali, tholeiitic and andesite basalts and by their degassing effects. The range of log σ limits

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ISSN 2455-4863 (Online) www.ijisset.org Volume: 3 Issue: 9 | September 2017

between -3.22 and 2.12 and log τ range between -1.11 and 2.88 indicating that they were derived from alkali basalt from non-orogenic region [15]. The negative logarithmic values also indicated the same feature. However, they were subjected to extensive degrees of volatiles under different tectonic setting of lava [15]. Silica and alkali saturated rocks in TAS diagram [16] showed intermediate type of rocks with increasing viscosity of melt. The depletion of alkalis with enrichment of silica, tholeiitic and andesite rocks form while silica under-saturated and alkali enriched volatile bearing gas-bubbles form foidal rocks.

Tabke1: *Wet-gravimetric chemical composition and their Rittmann's norm of extruded rocks from different places*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Si-pele	Siru	Siru	Siru	Abish	Abish	Abish	Abish	Thiru	Thiru	Thiru	Thiru	Thiru	Vada	Vada	Naga
SiO2	62.14	48.38	49.30	71.27	60.99	58.60	73.93	14.09	47.35	47.44	64.54	78.84	68.49	63.71	69.26	62.07
Al2O3	7.13	12.05	6.61	0.89	11.50	14.26	1.74	1.03	4.74	4.59	11.96	5.16	5.43	10.32	1.94	6.28
Fe2O3	10.95	11.54	16.84	10.76	16.40	6.57	7.73	9.04	18.57	19.40	2.52	8.30	15.81	8.60	11.39	11.80
FeO	9.52	3.41	4.29	3.08	0.00	7.22	4.60	36.64	8.27	6.59	2.01	3.30	3.78	6.98	5.93	7.52
MgO	1.40	3.96	4.05	2.79	2.46	1.10	2.40	2.21	7.58	7.92	3.95	0.70	1.65	2.60	3.59	0.47
CaO	4.24	13.93	13.39	7.22	6.89	10.47	6.10	8.44	10.37	10.81	10.41	1.64	2.03	4.85	4.40	8.01
Na2O	1.28	3.53	2.55	2.34	0.68	0.01	1.56	0.27	1.45	1.49	2.42	0.66	0.89	1.50	1.71	1.33
K2O	2.62	2.28	2.13	0.94	0.61	1.17	1.40	0.61	0.00	0.00	1.65	0.46	0.83	0.92	1.14	1.64
TiO2	0.73	0.91	0.85	0.71	0.47	0.59	0.55	27.67	1.68	1.75	0.54	0.93	1.09	0.52	0.65	0.87
Sum	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ox	0.51	0.75	0.78	0.76	1.00	0.45	0.60	0.18	0.67	0.73	0.53	0.69	0.79	0.53	0.63	0.59
τ	7.97	9.34	4.80	-2.04	23.13	24.26	0.33	0.03	1.96	1.77	17.75	4.86	4.17	17.06	0.35	5.71
σ	0.79	6.28	3.47	0.38	0.09	0.09	0.28	-0.03	0.48	0.50	0.77	0.04	0.12	0.28	0.31	0.46
	Rittmann's Norm															
il	1.02			0.24	0.66	0.71	0.24	47.40			0.51	1.45	0.00	0.65	0.30	1.27
mt	3.13	3.08	4.88	3.03	1.56	1.24	1.73	2.88	2.64	2.27	0.62	1.15	2.20	2.01	2.58	1.21
ol		32.72	10.41					45.62	1.44	3.94						
cpx	15.17	7.60	50.21	48.28	15.85	17.31	22.74		49.40	51.97	31.42		3.43	5.38	41.34	34.66
ac							12.38								9.83	
hy	21.25				19.33	12.15				24.43		15.60	28.62	24.29		6.17
cord												2.06				
san	28.66	14.16	34.51	4.22	2.82	3.56	15.54		28.87		8.52	3.26	4.22	3.19	6.53	16.52
pl	6.32	42.43			32.71	40.96	0.00		17.65	17.38	38.69	14.81	19.27	36.47	0.00	11.01
ne								4.11								
qz	24.44			44.24							20.25	61.67	42.26	28.01	39.42	27.16

Total alkali-silica diagram [16] increase of both Na_2O + K_2O vs SiO_2 increase of viscosity of lava. The depletion of SiO_2 was compensated by enrichment of gas-bubbles. The different degrees of degassing, magmatic decompression and viscosity changes were controlled by tectonic setting and mode of extrusion under intra-plate volcanism.

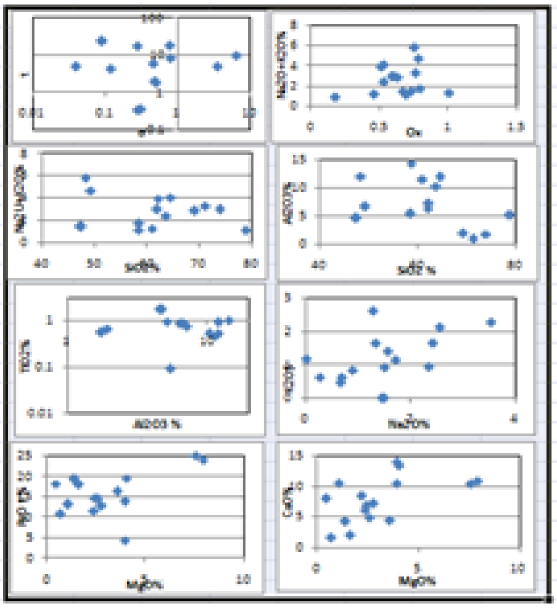


Fig 5: *Chemical variation diagram for wet-gravimetric chemical analyses of samples collected from different parts of Tamil Nadu.*

From EDAX analyses the major elements were recalculated and normalized to 100% were tabulated (Table-2) and their chemical variation diagram were drawn (Fig:-6). The analyses showed lower proportions major oxides than wet-gravimetric chemical analyses normalized to 100%. The one of the cause was due presence of certain trace elements and volatiles. The low concentrations of trace elements were magnified to 2 to 3 orders and determined their per cent.

Table 2: *EDAX analyses of basalt from Sirukinaru and their Rittmann's norm and trace elements*

SiO2	56.25	55.69	55.76	55.38	55.06	51.45	59.23	59.18	55.42	56.30	58.67	56.57	57.40
Al2O3	19.10	21.46	23.29	22.34	21.49	22.95	23.02	24.36	19.94	26.93	25.97	27.62	27.28
FeO	3.90	2.75	1.82	2.09	2.53	1.61	1.81	1.93	9.95	6.88	5.42	4.46	0.67
MnO	0.29	0.26	0.00	0.53	0.17	0.00	0.00	0.27	0.31	0.21	0.39	0.08	0.23
MgO	3.74	4.27	5.09	4.83	4.76	6.38	4.33	4.26	2.42	5.14	2.44	3.71	1.08
CaO	9.21	7.20	4.81	4.72	5.58	7.59	1.91	2.29	5.06	2.08	4.03	3.11	3.70
Na2O	5.60	6.96	8.08	8.68	8.53	9.77	8.14	6.02	3.00	0.76	1.60	3.02	8.76
K2O	1.13	0.86	0.78	0.87	1.02	0.24	1.05	1.05	2.31	0.84	0.87	0.77	0.60
TiO2	0.77	0.55	0.37	0.56	0.85	0.00	0.50	0.64	1.59	0.87	0.60	0.66	0.28
	Rittmann's Norm												
sp	0.00	0.00	0.68	0.00	0.00	0.00	8.07	15.02	5.70	32.12	20.09	21.70	5.59
il	0.92	0.69	0.47	0.68	1.00	0.00	0.65	0.85	2.25	1.22	0.85	0.91	0.37
mt	1.25	1.01	0.74	1.05	1.00	0.72	0.73	0.69	2.98	1.06	1.11	1.04	0.35
ol	0.00	6.12	10.13	8.97	6.83	7.41	4.54	1.18	7.94	0.00	0.00	0.00	0.00
or	0.81	4.54	3.94	4.30	5.00	1.08	5.91	6.01	13.84	4.99	5.21	4.50	3.31
ab	0.00	46.32	49.47	46.62	43.35	26.71	69.32	52.07	27.28	6.86	14.57	26.80	70.25
an	0.00	22.95	22.53	17.99	15.57	14.72	8.99	10.96	25.48	10.39	20.20	15.28	17.39
cpx	60.40	10.09	0.00	3.61	9.40	17.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hy	11.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
qz	24.77	0.00	0.00	0.00	0.01	0.00	1.78	13.23	14.54	43.37	37.97	29.74	0.00
ne	0.00	8.27	12.03	16.78	17.83	31.70	0.00	0.00	0.00	0.00	0.00	0.00	2.74

Dha	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Y	0.28	0.19	0.2	0.36	0	0.16	0.72	0.18	0.76	0.28	0.19	0.2	0.36	0.92	1.83	1.99
La	0.54	0	0.15	0.34	0.81	0.36	0.5	0.43	0.36	0	0.76	0.27	0.37	0.68	0.84	0.84
Ce	0.61	0	0.25	0.45	1.03	0.35	0.47	0.39	0.45	0.21	0	0	0	0.62	0.55	0.58
Nd	0.33	0	0.17	0.27	0.43	0.19	0.3	0.28	0.33	0.31	0.08	0.05	0.06	0.4	0.52	0.56
Eu	0.39	0	0.45	0.11	0.65	0.25	0	0.42	0.15	0.19	0	0.06	0.04	0.35	0.13	0.52
Dy	0.69	0.35	0.26	0.25	0.3	0.5	0.74	0.89	0.41	0.45	0.05	0.59	0.62	0.49	1.17	1.05
Yb	1.05	0.4	0	0.17	1.16	0.46	0.57	0.47	0.58	2.11	1.34	0.92	1.16	0.18	0.63	0
Lu	0.56	0.13	0	0.1	0.85	0.31	0.48	0.45	0.37	0.27	0	0.2	0.27	0.95	0.66	0.63
Hf	0.71	0.17	0	0.19	0.75	0.39	0.44	0.49	0.32	0.54	0	0.15	0.34			
Zr	0.21	0	0	0	0	0	0	0	0	0.61	0	0.25	0.45	0.73	2.13	2.45
Ta	1.03	0.17	0	0	0.59	0.3	0.33	0.6	0.29	0.33	0	0.17	0.27			
Nb	2.53	0.4	0	0	0.36	0.43	0	0	0	0.39	0	0.45	0.11	2.09	1.96	2.65
Pb	1.01	0.48	0	0	0.78	0.64	0.71	0.73	0.51	0.07	0	0	0.15			

These diagrams show trends of increasing degree of Al_2O_3, FeO, alkalis and CaO in ordinate against their respective abscissa. The escape of volatiles trends of degassing of volatiles moved diagonally with positive linearity.

5. DISCUSSION

Many geologists assumed that formation of tube-like earthy materials as fulgurites generated by lightning strike [17-20]. However it was enigmatic. There were giant exposures of ironstone in sandstone covering several hundreds of m^3 in Blue Mountains of Australia. The ironstone had tube kike structure over 50 cm diameter and had steep dips towards inner side creating basin like structure. Similarly there were linear limestone outcrops extending over 100m in Malta Island. They were assumed to be as fulgurites by some geologists [21]. However volcanic rocks do form as tube like structure glossy inside. More detailed studies are required. Micro-bubbles in plumes derived from lower-mantle region [22] do emplace as root-less lava on the surface of the Earth.

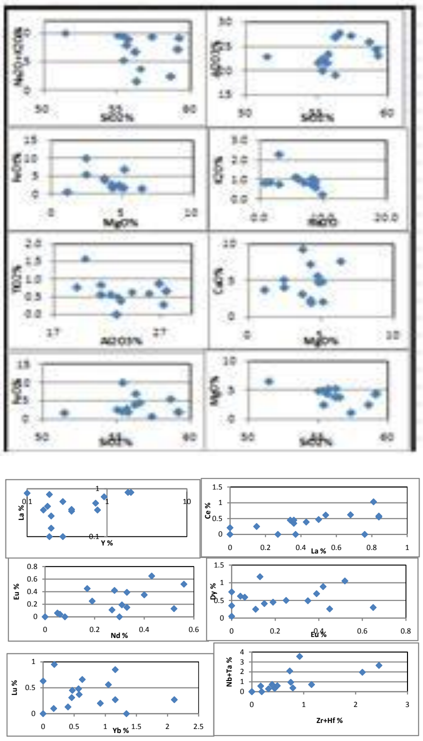


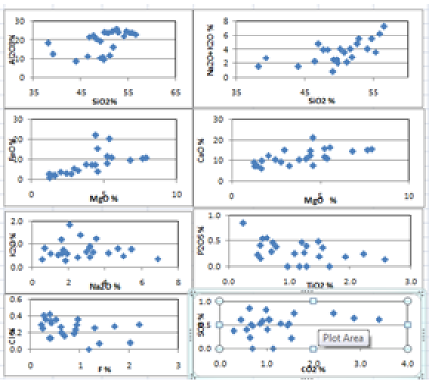
Fig 6: *Chemical diagrams for Table 2. Increasing degree of volatile-degassing a trend moves diagonally.*

Table 3 Major oxides and volatiles (except water) were recalculated from EDAX analyses of Vadamambakkam and their trace elements

Arakko	AR-1	AR-2	AR3	AR4	AR5	AR6	AR7	AR8	AR9	AR10	aR11	AR13	AR14	AR15	AR16	AR17	AR18	AR19	AR20	AR21	AR22	AR23	AR24
SiO2	48.35	54.72	51.62	55.30	52.60	50.83	49.13	54.15	46.93	39.28	38.23	47.69	50.13	51.91	51.19	56.63	49.80	49.08	52.92	43.97	55.97	46.45	49.72
Al2O3	20.78	24.55	24.65	23.92	26.29	23.97	19.54	22.18	21.53	12.52	18.29	22.29	24.37	16.30	11.50	22.78	9.51	10.58	24.17	8.36	23.75	11.22	10.78
FeO	7.53	0.96	3.09	2.85	1.95	3.73	7.50	4.55	5.59	22.32	20.54	7.71	4.07	8.27	9.79	2.29	10.60	10.98	2.80	15.52	2.25	11.10	11.68
MgO	4.19	1.27	2.45	2.77	1.66	2.05	4.43	3.23	2.96	4.44	5.38	3.78	4.59	5.23	6.83	1.64	7.67	7.90	1.24	4.58	1.42	5.54	5.23
CaO	10.88	7.36	10.50	9.38	9.95	12.32	12.41	7.55	15.01	14.62	11.08	10.46	7.70	11.75	14.45	6.21	15.05	15.46	9.20	20.98	7.40	16.30	15.76
Na2O	3.15	5.01	3.36	2.98	4.19	3.18	1.72	3.18	3.53	1.61	1.02	2.06	2.64	2.50	1.84	6.90	1.44	0.55	4.70	0.68	5.46	1.66	1.92
K2O	0.86	0.48	0.65	0.67	0.61	0.43	0.75	0.91	1.24	1.20	0.59	1.85	1.40	0.42	0.28	0.35	0.54	0.33	0.81	0.83	0.78	0.61	0.59
TiO2	1.67	0.56	0.74	0.97	0.53	0.71	1.25	0.63	1.09	1.50	1.21	1.29	0.79	1.29	1.49	0.48	1.56	1.94	0.53	2.59	0.24	2.23	1.17
P2O5	0.00	0.54	0.46	0.00	0.15	0.29	0.27	0.55	0.25	0.19	0.46	0.40	0.38	0.00	0.48	0.23	0.36	0.19	0.41	0.14	0.84	0.25	0.00
F	0.69	0.22	0.30	0.24	0.62	0.41	0.96	0.42	0.39	0.62	1.30	0.26	0.41	1.18	1.39	0.88	2.21	2.02	0.93	0.52	0.38	0.91	1.70
Cl	0.16	0.30	0.36	0.25	0.27	0.14	0.36	0.32	0.42	0.20	0.26	0.41	0.34	0.00	0.07	0.19	0.30	0.08	0.29	0.36	0.14	0.24	0.28
CO2	1.53	3.41	1.30	0.30	0.67	1.45	1.07	1.59	0.45	0.91	1.04	0.99	2.43	1.14	0.70	1.02	0.57	0.65	1.48	0.63	0.86	2.87	0.70
S	0.21	0.61	0.53	0.37	0.50	0.49	0.61	0.74	0.61	0.58	0.61	0.81	0.74	0.00	0.00	0.40	0.40	0.23	0.52	0.84	0.52	0.64	0.48
Sum	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
τ	10.57	34.66	28.91	21.48	41.75	29.09	14.23	29.94	16.50	7.27	14.28	15.68	27.50	10.66	6.51	32.83	5.19	5.18	37.07	2.97	74.81	4.28	7.57
σ	0.75	0.47	0.47	0.30	0.50	0.46	0.40	0.37	1.21	-0.76	-0.34	0.83	0.57	0.33	0.26	0.53	0.29	0.15	0.55	1.56	0.48	0.66	0.37
Arakko	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
anh	0.32	0.87	0.75	0.55	0.65	0.65	0.89	0.98	0.87	0.80	0.90	1.10	0.98	0.00	0.00	0.53	0.55	0.33	0.75	1.27	0.76	0.89	0.66
cc	3.79	8.41	3.23	0.77	1.62	3.57	2.66	3.94	1.09	2.40	2.69	2.42	5.96	2.84	1.75	2.43	1.42	1.64	3.65	1.61	2.16	7.20	1.76
nc	0.54	0.87	1.08	0.77	0.86	0.43	1.11	0.98	1.30	0.69	0.78	1.21	1.08	0.00	0.22	0.53	0.87	0.22	0.86	1.15	0.43	0.78	0.88
caf	2.92	0.87	1.29	1.04	2.59	1.78	4.15	1.81	1.63	2.80	5.71	1.15	1.79	5.08	5.98	3.65	9.49	8.81	3.97	2.36	1.62	3.99	7.41
ap	0.00	1.15	0.86	0.00	0.27	0.59	0.61	1.15	0.60	0.46	1.06	0.88	0.70	0.00	1.04	0.42	0.44	0.44	0.86	0.29	1.73	0.44	0.00
il	2.27	0.76	0.97	1.32	0.76	0.97	1.60	0.88	1.52	1.94	1.68	1.76	1.08	1.64	1.48	0.63	1.64	2.52	0.00	2.76	0.32	2.82	1.32
mt	0.70	0.11	0.38	0.33	0.27	0.49	1.44	0.60	0.71	3.32	1.96	0.99	0.54	1.09	1.15	0.53	1.04	1.04	0.43	1.61	0.43	1.27	1.65
ol	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.32	28.82	23.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.00	0.00	0.00
cpx	0.00	0.00	0.00	0.00	0.00	0.00	4.48	0.00	13.96	19.10	0.00	0.00	0.00	27.40	43.31	0.00	47.19	46.69	0.00	57.72	0.00	40.42	45.01
cord	2.87	10.16	17.09	11.05	15.82	7.36	0.00	29.70	0.00	0.00	13.44	10.49	42.63	0.00	0.00	15.86	0.00	0.00	15.44	0.00	15.53	0.00	0.00
sil	0.00	16.28	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	3.22	0.00	2.43	0.00	0.00
hy	17.86	0.00	2.96	5.77	0.00	6.38	16.71	2.30	0.00	0.00	4.59	14.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
san	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	5.95	3.47	7.58	3.25	0.00	0.00	0.00	0.60	0.82	0.00	2.71	0.00	0.00	0.00
pl	68.24	50.36	64.20	68.61	73.92	72.85	58.33	47.10	65.34	33.73	40.03	55.57	37.38	55.24	37.61	73.08	29.62	28.46	65.84	24.54	70.28	35.88	35.29
ne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	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
qz	0.00	10.16	7.17	9.79	3.02	4.92	8.02	10.56	0.00	0.00	0.00	2.80	4.60	6.71	7.46	1.48	7.69	9.03	4.99	0.00	4.31	6.31	6.04

Ara	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Y	1.25	0.22	0.72	0.62	0.52	0.51	0.88	1.34	0.52	1.37	0.57	2.41	0.88	0.48	1.23	0.29	0.76	0.71	0.53	1.6	0.3	1.4	1
La																							
Ce	0.49	0.62	1.07	1.09	0.9	0.56	0.59	1.32	1.47	0.4	0.64	1.98	0.46	0.46	0.25	0.37	0.28	0.32	0.65	1.58	0.28	0.74	0.42
Nd	0.38	0.55	0.45	0.53	0.28	0.6	0.78	1.24	1.11	0.51	0.37	1.42	0.32	0.32	0.11	0.42	0.66	0	0.33	0.96	0.55	0.3	0.74
Eu	0.76	0.56	0.93	1.02	0.83	0.87	1.24	1.19	1.98	1.44	0.92	2.37	0.5	0.65	0.64	0.45	0.97	0.45	0.65	1.6	0.44	0.7	1.22
Dy	2.14	0.84	1.71	1.75	0.9	2.05	2.52	3.04	2.72	6.29	5.75	4.57	0.91	3.27	3.49	0.58	2.37	3.7	0.81	4.98	0.53	4.59	2.92
Tb	0	0.25	0	0.61	0.25	0	0.29	1.16	0.41	0	0	0.17	0.03	0.4	0	0	0	0	0.31	0	0	0	0
Lu	0	0.92	1.01	0.7	0.74	0.81	0.7	0	1.9	0	0	1.61	0.3	0	0	0.63	0.24	0	0.58	0.75	0.61	0	0.59
Hf	0.44	0.82	1.22	0.85	0.41	0.51	0.47	0	1.61	1.09	0.72	2.39	0.43	0.67	0.77	0.98	0.71	0.44	0.63	0.94	0.9	0.56	0.67
Zr	1.62	0.34	0.31	0.48	0.86	0.98	0.45	0	1.46	0.63	1.7	1.47	0.52	0	0.94	0.32	0.88	0.45	0.89	2.34	0.77	1.58	1.22
Ta	0.51	0.48	1.05	0.82	0.87	0.61	0.53	0	2.3	0.66	1	1.26	0.23	0.59	0.95	0.62	0.74	0.23	0.51	1.23	0.75	0.67	1.28
Nb	1.84	0	0	0.39	0	0.92	0.96	0	1.7	2.96	2.18	0	0	0.93	1.15	0	0.65	0.71	0.4	2.22	1.32	0.98	1.93
Pb	1.02	0.56	0.85	1.05	1.26	1.28	1.17	1.7	3.12	2.48	1.46	1.95	0.31	1.58	1.34	1.31	1.5	1.34	1.14	2.05	0.92	1.69	1.39
U	2.42	0.99	2.57	2.45	1.53	2.73	1.73	3.69	2.31	1.5	2.55	2.49	0.34	0.8	2	1.92	1.07	2.39	2.34	4.21	1.02	1.63	1.61
Sr	1.12	0.25	0.66	0.34	0.88	0.7	0.95	0.62	1.26	1.61	1.19	1.49	0.55	1.37	1.01	0.54	0.82	0.6	0.69	1.02	1	0.87	0.7
Ba	0	0.1	0	0	0.28	0	0.75	0.67	0.92	0.19	0	0	0	0	0	0.3	0.64	0	0	0	0.52	0	1.29

The Table 3 indicates that SiO_2 varies from 38.23 to 56.63%.



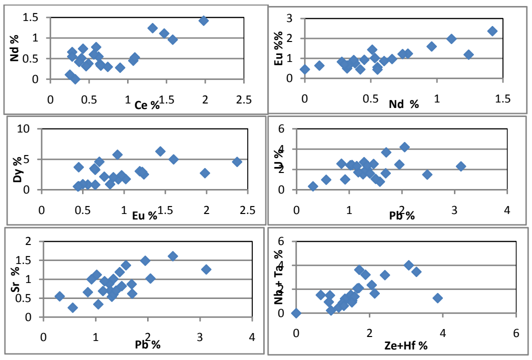


Fig 7: *Chemical diagrams for Table.3 which includes P_2O_5, SO_3 CO_2, F, and Cl. The above diagrams indicate more positive linear variation indicating high degree of degassing [15]. The characteristic incompatible trace elements show more linear variation due to degassing in Fig. 6 and 7.*

In Tamil Nadu, carbonatite-tuffs and lava and silicate perovskite [23] were extruded from deep mantle source on the ground-surface through major fault planes [8]. In such cases, there were more possibilities of formation of tube like forms glossy inside due to escape of volatiles. The size of bubble bearing plume at 4000°C and 135GPa vary widely from <1mm to >1000mm dimension nucleating at depth increasing in volume at near surface condition owing to rapid decreasing of pressure (decompression) from >135Gpa to 1 bar on the surface where volatile degassing is crucial forming as rootless eruption [23]. Some alkalis dissolved or exsolved in water also escape during degassing leading to form residual sub-alkaline (tholeiitic) and andesite instead foidal rocks [16]. The cavities and tubes formed by escape of gases from silicate melt or basaltic lava have smooth glossy surfaces inside [23].

The loss and retention of dissolved and exsolved volatiles during magma ascent control eruption style of melt. PTX and volatile content might have been changed viscosity of the melt. Increasing-viscosity of the melt control pre-eruptive and eruptive style [24] of the melt. Micro-plume carrying immiscible bubbles of exsolved and dissolved volatiles, generated at deep lower mantle rapidly ascent at the rate from <100 to >200m/s. It rapidly ascents through fault plane with little friction and loss of potential energy with decreasing pressure and increasing temperature maintaining its plasmatic state [23]. Near the surface, bubbles containing volatiles burst and emit lava-flow with different style of effusion or eruption. Such types of volcanism do not have any roots below orifice [23]. Escape of volatiles by high-temperature burst of bubbles and tubes create smooth glossy surfaces inside vesicles. At different sites of an EDAX sample of glasses within 1mm^2 show wide variations in chemical compositions by increasing viscosity, eruption style of the melt This leads to change in pressure, temperature and chemical composition of the melt. Bulk compositions of vesicular rocks were estimated by wet-gravimetric analyses did not match the composition any individual site of EDAX.

The host rocks around the orifices of extrusions were granite gneisses and any melting of such host rocks did not represent basaltic composition. The enigmatic occurrences of carbonate in Malta Island and the Ironstone in sandstone in Blue Mountain, Australia were deserved for further studies whether they were formed by high energy plasma discharges in an electric-universe [12]. Lightning strike on ground surface might have been produced by local plasma flux on siliceous material that could not be correlated with such wide variation of any basalt, carbonate and ironstone [12].

Tectonic setting under convergent margins, orogenic belts (Island arcs) subjected to intensive folding and faulting, large quantities of volatiles escape rapidly and andesite lava could be formed. Under divergent plate boundary in mid oceanic ridge basalts (MORB) rapidly chilled and quenched basalts sealing vents partially have intermediate abundance of volatiles. On the other hand intra-plate volcanism related with hot spots and plumes derived from deep mantle source loss volatile-bearing bubbles to a limited extend owing to rapid ascent. The degree of degassing was controlled by viscosity, PTX and concentration, of dissolved and exsolved volatiles in the melt.

6. CONCLUSION

Basalt is the wide-spread volcanic rock on the Earth's crust. The compositional variation of different types of basalts is attributed to their different types of tectonic settings under varying degrees of degassing effects leading to increasing viscosity of basaltic melt (1) divergent plate boundary, (2) convergent plate boundary and (3) intra-continental plate volcanism [25]. Basalts originate in all these tectonic settings. Viscosity variation in different types of basaltic melt causes transformation from one over the other. Viscosity of melt [26] directly depends up on composition, pressure, temperature, volume of crystal-microlites, time, size and volume concentration of volatile bearing bubbles and their escape under different eruption style controlling degassing effect. Increasing of viscosity of a basaltic melt, it transits chemical composition from alkali-basalt to tholeiite and to andesite or basanite to phonotephrite and to phonolite. Linear positive variation leads to trachy basalt and to trachy-andesite. However, water phase present in basaltic melt dissolved and exsolved alkalis and escapes during degassing of melt and residual melt depletes forming andesite melt in island arcs and orogenic belts. The intermediate escape of volatiles and alkalis produces flood basalts of tholeiitic composition. The limited escape of volatiles and alkalis forms alkali basalts in continental rifts. The present extrusions might have been related to late stages of Deccan trap volcanism [27]. TAS diagram illustrate degassing effect of basaltic melt under different tectonic settings. The lightning strike on the siliceous ground surface immediately disperse its potential energy and does not form vesicles and tubes with smooth glassy surfaces inside as in furnace clinker or lava flows. Micro-volcanic flows and eruptive materials are seen in several parts of Tamil Nadu [3, 4. 6,12, 27, 28, 29, 30]. The energy required for formation of fulgurites by lightning strike on ground surface immediately disperse and plasmatic flux of siliceous materials do not occur in large scale on ground surface. The geneses of fulgurites and basaltic eruption are contrasting events. The micro-basaltic action has distinct changes on viscosity of melt derived from different tectonic setting and eruption style.

List Item – 1 Article with 8 pages

List Item - 2 Seven figures

List Item – 3 30 References

List Item - 4 Author's bibliography with photo

AKNOWLEDGEMENT

The author gratefully thanks Late Prof. S. Saravanan who promoted my self-thinking and Late Mrs Kasthuri Saravanan who perfectly maintained "Thayinum Salap Parintha Guru-Sisya Parambariya" between July 1967 and July 1973 during my Ph.D., research-period in Presidency College, Chennai.

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