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Petrographic, mineralogical and microstructural studies in the mafic dyke occurred in the area of Mettur, Salem District, Tamil Nadu, India

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Abstract

A mafic dyke is a mass of rock generated in either sedimentary or igneous terrain and intrudes in pre-existing cracks. It was common to see many enormous dyke swarms in the southern granulitic landscape made up of archean rocks. Dykes tend to be younger than the surrounding rock body. Generally, mafic dolerite dyke has an ophitic texture and is medium to fine grained. In the study area country rock and dolerite dyke rocks petrographical microscope, XRD, and FE-SEM techniques were analysed. Plagioclase feldspar, augite, biotite, hornblende, and quartz minerals presented in the study area rocks. Alternating wedges, augite/labradorite grain boundaries are shown in the microstructure as a white rectangle. Two augite wedges were observed with rounded ends. The mineral percentage of quartz is rich in dolerite rock because of its intergrowth texture and low cooling temperature and pressure. So, the magma crystallized rapidly on the surface thus, the crystallizing temperature of the quartz is low. Thus, the rock mineral shows a high percentage of quartz. The rock is quartz-dolerite.

Keywords: Dyke; Petrography; Mineralogy; Microstructure; Quartz-Dolerite.

1. Introduction

Many of the Archaean gneissic terrains contain early Proterozoic dyke swarms as a common unit. The widespread occurences is that partial melting in the mantle produced mafic dykes. However, little or microscale differences in various mafic dykes and other mantle-derived rocks, such as mantle xenoliths, have shown that the composition of mantle-derived rocks can differ greatly from the source. In general, there are two possible causes for variations in the composition of mafic rocks: first, variations in the source mantle; and second, variations in the processes of magma generation, such as the degree of partial melting or variations in the magmatic processes, such as fractional crystallisation and crustal assimilation. Typically, mafic dykes are connected to the extension of the continental lithosphere [1, 2, 3, 4] and their parent magmas came from sources in the deep mantle, opening a window to study the nature of the deep mantle and the development of the lithosphere [5]. The primary pathway by which mantle melts are delivered to the crustal levels is through the mafic dykes. These are important features, and in some cases, the sole significant Proterozoic geologic event that affected the Archaean cratons [6]. Although a few intrude Paleozoic sedimentary strata of the valley and ridge province, the majority of dykes are found in the Piedmont province. Individual dykes can be up to 100 km long, and local swarms can be up to 225 km long [7]. Although 300 m ± thick dykes exist [8], the majority are less than 30 m wide [9, 10]. Dykes occur in a wide variety of geological and tectonics settings and their detailed study through space and time is imperative for understanding several geological events. Dykes are believed to be an integral part of continental rifting and when they occur as spatially extensive swarms of adequate size can be of immense utility in continental reconstructions. This also helps to identify large igneous provinces (LIPs) [11]. Dykes are particularly important for serving as conduits for the transfer of voluminous magma from the mantle to the upper crust and thereby constitute a common expression of crustal extension. It is also well acknowledged that the continental flood basalts and major dyke swarms have their origin related in some way to the up-rise of hot mantle plumes which may

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lead to rifting and eventual continental break-up [12]. According to [13], dykes appear to have been formed by upwelling magma which mainly followed joints and cross faults. Most dykes are fairly straight, continuous, and parallel except where abundant longitudinal faults occur. The dip of most dykes is nearly vertical, but several have been observed to dip as low as 25°.

1.1. Geological setting of the study area

The study area is located near to the Yellikkaradu Village of Mettur Taluk of Salem District, Tamil Nadu, South India. The study area is located at a distance of 48 km towards the northwest of Salem, which is the headquarter of Salem District. The study area is marked in the Survey of India toposheet number 58E/9, 10, 13 & 14 with the coordinates 77°46’41” E and 11°46’23” N. The mafic dyke occurs on the eastern slope of the steep hill. The general trend of the dyke is N 50° to 60° W to S 50°- 60° E and dipping vertically. The study area dyke runs for several kms. However, for this study, we have taken about 800 m length of dyke body, the reason is that only a certain part of the area is approachable and convenient for collecting samples and preparing maps. The area receives moderate rainfall (40 cm per annum) and the rainy period is mainly due to the NE monsoon from October to December every year. The summer is hot with a maximum temperature of up to 36°C. The geological map of the study area is shown in Fig.1.

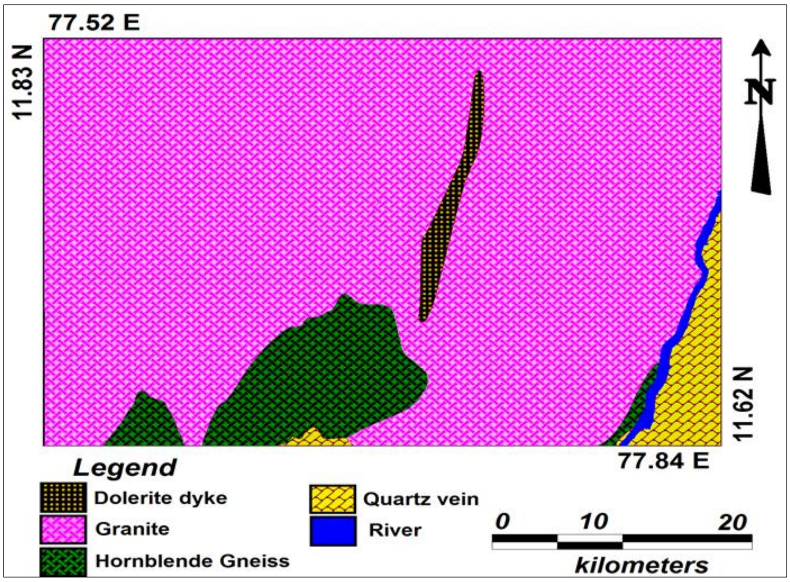

Figure 1 Geological map of the study area

2. Material and methods

2.1. Sample collection

Systematic fieldwork has been carried out to investigate the dolerite dyke of the study area. During the fieldwork ten representative specimens, including the dyke rock and country rock were collected. Generally, dyke is a uniform and homogenous body. So, in this study, two dyke samples and one country rock sample were taken for the analytical studies. The samples underwent for petrographical, X-ray diffraction and SEM analysis studies.

2.2. Sample preparation

2.2.1. Thin section preparation

The collected representative specimens were taken to the laboratory for preparation of thin sections. The thin sections were prepared by standard procedures, thin sections were made by the Department of Earth Sciences, Pondicherry University, Puducherry.

2.2.2. Powder samples for mineralogical analysis

The dried rock samples were crushed and pulverized into fine powder with the help of iron mortar. The powder samples were pouched, separated and sent for XRD analysis in order to understand mineralogical measurements. The XRD analysis performed at Department of Chemistry, Annamalai University.

2.2.3. Specimens for microstructure analysis

Samples were washed and dried at room temperature, and then the samples were cut and polished in the rock cutting and grinding lab, Department of Earth Sciences, Annamalai University. The polished specimens were coated for secondary imaging for microstructural investigations in the Central Sophisticated Instrumentation Lab (CSIL), Annamalai University.

2.3. Analytical method

2.3.1. Petrography

The microscopic investigations of thin sections were carried out at the Department of Geology, Periyar University, using a LEICA DM 2700P petrographic microscope. The minerals were investigated in plane polarised light (PPL) and crossed polarised light (XPL). The petrographical microscope was used to conduct in-depth textural and mineralogical examinations.

2.3.2. Mineralogy

The mineralogical characteristics of the dolerite and charnockite samples were determined using ARLEQUINOX 1000 X-RAY Diffractometer.

2.3.3. Microstructure

To examine the microstructures of the rocks, the dolerite and charnockite rock specimens are subjected to a field emission scanning electron microscope. It was carried out at Annamalai University's Central Sophisticated Instrumentation Lab. A Scanning Electron Microscope Eds Zeiss-Sigma 300fesem with the edax specification was used for the analysis.

3. Results and discussion

3.1. Dolerite (S1)

The important minerals, including augite, plagioclase feldspar, and opaque minerals, are depicted in dolerite (S1) the photomicrographs shown in Figure 2. In the sample dolerite (S1), biotite exhibits brownish colour and pleochroism display observed. The dykes generally have a sub-ophitic texture. True ophitic texture typically appears in the centre of dykes that are greater than 25 feet thick [14]. The grains show a subhedral shape and sub-ophitic texture. The effects of secondary alteration are shown by the presence of biotite, sericite, chlorite, serpentine, iddingsite and magnetite in concentrations up to 5% [15]. The edges of augite are altered to hornblende. The quartz and feldspar show intergrowth (granophyric) texture. The groundmass minerals show that the pyroxene began to crystallize before plagioclase. The specimen shows inter-mineral fracture under the microscope.

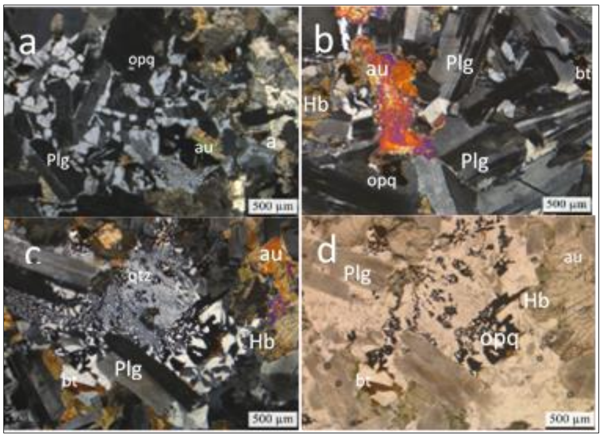

Figure 2 Photomicrographs: (a) thin section of dolerite with the presence of plagioclase feldspar (Plg), augite (aug) and opaque minerals. (b) thin section of dolerite with the presence of augite (aug), plagioclase feldspar (plg), hornblende (hb), biotite (bt) and opaque minerals. (c) thin section of dolerite with the presence of quartz (qtz), biotite (bt), augite (au), plagioclase feldspar (plg), and (d) plagioclase feldspar (plg), biotite (bt), augite (au), hornblende (hb) and opaque minerals.

3.2. Dolerite (S2)

The Figure 3, exhibits the photomicrographs of dolerite (S2). The essential minerals observed are plagioclase feldspar, augite, and opaque minerals. Biotite shows brownish colour, pleochroism and interference colour present in the sample. Augite shows violet, blue, and yellow as interference colours. The inclusions in the plagioclase are iron oxides mainly magnetite. The opaques consist of magnetite and sulphides (pyrite/pyrrhotite) in order of abundance. The laths of plagioclase show polysynthetic twinning and a cloudy appearance. The augite shows contact twinning, basal cleavage and edges altered to hornblende. Plagioclase edges show few sericite alterations. In this section, skeletal opaque intergrowth with granophyric texture observed.

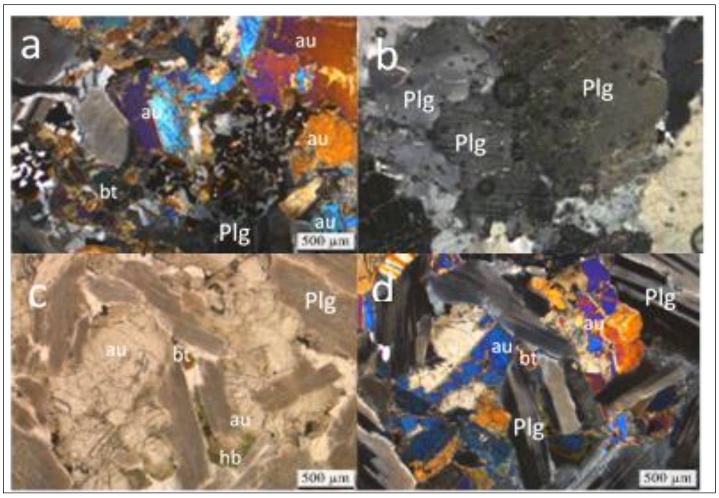

Figure 3 Photomicrographs of dolerite (S2) showing (a) thin section of dolerite with the presence of plagioclase feldspar (Plg), biotite (bt), augite (aug) and opaque minerals. (b) thin section of dolerite with the presence of plagioclase feldspar (plg). Photomicrographs under polariser showing (c) plagioclase feldspar (plg), biotite (bt), augite (au), and hornblende (hb) and (d) thin section of dolerite with the presence of biotite (bt), augite (au) and plagioclase feldspar (plg).

3.3. Charnockite (S3)

The photomicrographs (Fig. 4) show plagioclase and microcline quartz, biotite and hypersthene and opaque minerals. The grain size is medium to coarse and inequigranular. Sericite is the alteration product of plagioclase and quartz. Zircon present shows parallel extinction. The quartz and k-feldspar show intergrowth myrmekitic texture also observed.

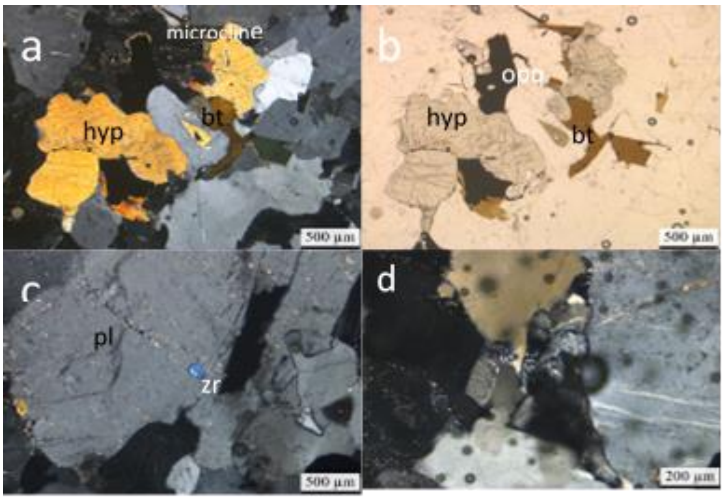

Figure 4 Photomicrographs under analyser showing (a) microcline, biotite (bt) and hypersthene (hyp). (b) plagioclase feldspar (plg), biotite (bt), hypersthene (hyp) and opaque minerals. (c) showing plagioclase feldspar (plg) and zircon (zr) and (d) showing intergrowth texture of quartz and microcline.

3.4. Mineralogy

3.4.1. Dolerite

The X-ray diffraction has shown to be one of the best tools for the identification and quantification of minerals present rock in soil [16]. Mineral compositions revel that the complex petrogenetic evolutions which usually characterize doletrite dykes of continental setting [17, 18]. The mineral composition of the dolerite is composed of quartz, augite and plagioclase feldspar. Among the 51 XRD peaks 3 phases were identified, 23 peaks represent quartz mineral, 20 peaks report augite and the remaining 8 peaks reported plagioclase feldspar. The XRD pattern of dolerite is shown in Figure 5.

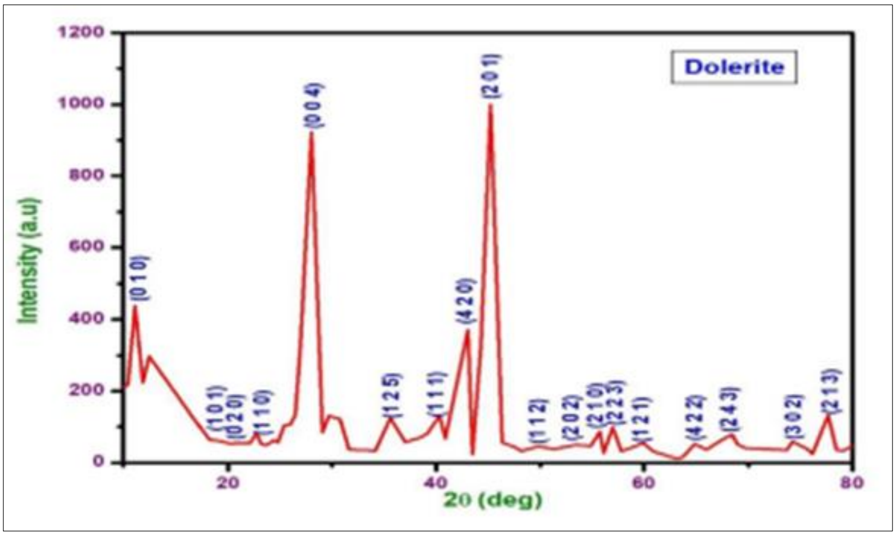

Figure 5 The XRD pattern of dolerite rock sample.

All the observed characteristic peaks (planes) are tabulated. From this, all the major and minor peaks are well matched with the dolerite mineral composition of JCPDSNo: 89-0572, and 88-2376. This indicates that the sample is in the form of dolerite. From this figure, the intensity of quartz planes is high compared with other minerals. It clearly shows, the presence of a large proposition of quartz in dolerite mineral (Ref. Table1). Some low-intensity peaks represent the minerals in trace levels in dolerite. Dolerite is composed of two essential and several accessory minerals. The essential minerals are plagioclase feldspar and pyroxene, which together constitute between about 60% and 80% of the total rock composition. The accessory minerals are quartz, orthoclase, chlorite and magnetite. Quartz, orthoclase and chlorite may comprise 20% to 40% of the rock while the magnetite composition may be consist 2% to 3%.

Table 1 XRD peak value details of dolerite rock

2 theta S [º]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM	Hkl value	Size (nm)	Phase Name	JCPDS File No.
11.09	7.9695	437.26	26.86	0.2411	0 1 0	34.618	Quartz	89-0572
12.48	7.0870	297.42	28.99	0.3827	1 1 0	21.78196	Augite	88-2376
18.18	4.8767	63.75	8.64	0.5321	1 0 1	15.5616	Quartz	89-0572
19.02	4.6622	61.41	7.69	0.4919	0 2 0	16.81316	Augite	88-2376
20.17	4.3999	53.83	6.95	0.5066	1 0 0	16.29702	Quartz	89-0572
22.92	4.2431	54.88	6.28	0.4494	1 1 0	18.28763	Quartz	89-0572
23.69	3.7524	48.10	5.53	0.4515	1 1 1	18.17736	Augite	88-2376
24.41	3.6428	62.84	5.42	0.3384	1 1 1	24.22016	Augite	88-2376

25.38	3.5065	103.87	7.32	0.2765	1 3 2	29.58699	Plagioclase feldspar	20-0572
25.95	3.4304	106.27	8.05	0.2974	2 2 2	27.47659	Plagioclase feldspar	20-0572
26.46	3.3652	133.64	10.19	0.2994	1 1 4	27.26479	Plagioclase feldspar	20-0572
26.98	3.3024	331.07	25.52	0.3026	0 1 1	26.9474	Quartz	89-0572
28.03	3.1805	922.27	74.93	0.3189	0 0 4	25.51276	Plagioclase feldspar	20-0572
29.69	3.0066	131.22	9.39	0.2810	2 2 1	28.84607	Augite	88-2376
30.77	2.9030	120.95	12.96	0.4208	0 2 2	19.21373	Plagioclase feldspar	20-0572
31.65	2.8248	36.32	5.17	0.5590	1 3 2	14.43259	Plagioclase feldspar	20-0572
35.57	2.5220	123.75	10.46	0.3319	1 2 5	24.0581	Plagioclase feldspar	20-0572
37.04	2.4248	56.75	6.40	0.4427	1 3 1	17.96108	Augite	88-2376
38.40	2.3422	68.84	6.19	0.3532	1 0 2	22.42129	Quartz	89-0572
39.15	2.2989	80.45	7.88	0.3844	3 3 1	20.55406	Plagioclase feldspar	20-0572
40.30	2.2361	130.76	11.09	0.3329	1 1 1	23.6479	Quartz	89-0572
40.90	2.2046	67.74	6.94	0.4020	2 0 0	19.54516	Quartz	89-0572
43.04	2.0998	370.24	29.97	0.3177	4 2 1	24.55484	Augite	88-2376
43.49	2.0790	23.74	1.03	0.1697	4 2 0	45.89825	Augite	88-2376
45.24	2.0026	1000.00	61.42	0.2411	2 01	32.10527	Quartz	89-0572
46.36	1.9570	55.91	15.45	1.0850	1 32	7.104783	Augite	88-2376
49.85	1.8277	46.03	16.96	1.4467	1 1 2	5.256516	Quartz	89-0572
51.36	1.7775	37.38	13.20	1.3864	0 0 3	5.451078	Quartz	89-0572
53.38	1.7149	49.31	16.66	1.3262	2 0 2	5.649334	Quartz	89-0572
54.89	1.6714	46.75	9.33	0.7836	0 2 2	9.497021	Quartz	89-0572
55.73	1.6480	86.40	9.29	0.4220	2 10	17.56714	Quartz	89-0572
56.12	1.6375	26.57	9.38	1.3864	2 2 3	5.337531	Augite	88-2376
57.00	1.6144	98.21	16.59	0.6631	4 4 0	11.11362	Augite	88-2376
57.81	1.5936	32.73	3.52	0.4220	4 4 0	17.39568	Augite	88-2376
58.53	1.5756	38.48	7.68	0.7836	2 1 1	9.335583	Quartz	89-0572
59.95	1.5417	55.08	3.99	0.2841	1 21	25.56848	Quartz	89-0572
60.94	1.5189	30.43	6.48	0.8364	1 1 3	8.641246	Quartz	89-0572
63.21	1.4699	9.76	0.99	0.3992	3 3 3	17.89051	Augite	88-2376
63.72	1.4593	15.76	6.08	1.5133	3 0 0	4.706444	Quartz	89-0572

64.92	1.4351	51.88	10.72	0.8109	4 2 2	8.725514	Augite	88-2376
66.04	1.4136	35.73	3.90	0.4288	2 0 3	16.39737	Augite	88-2376
68.45	1.3695	77.66	5.98	0.3023	2 4 3	22.93596	Augite	88-2376
68.93	1.3611	51.24	2.64	0.2026	7 1 1	34.125	Augite	88-2376
73.66	1.2849	34.25	1.21	0.1391	3 0 2	48.25315	Quartz	89-0572
74.24	1.2764	57.84	2.88	0.1958	0 6 2	34.14956	Augite	88-2376
75.68	1.2556	37.30	3.19	0.3353	2 0 0	19.75057	Quartz	89-0572
76.17	1.2488	24.01	1.17	0.1919	55 2	34.39451	Augite	88-2376
77.67	1.2283	131.81	9.22	0.2747	2 1 3	23.7788	Quartz	89-0572
78.43	1.2184	34.25	5.22	0.5978	1 1 4	10.86821	Quartz	89-0572
79.12	1.2095	34.16	2.57	0.2957	1 71	21.86329	Augite	88-2376
80.26	1.1951	50.04	9.05	0.7101	3 1 1	9.029046	Quartz	89-0572

3.4.2. Charnockite

The XRD pattern of the charnockite is given in Figure 6, and the mineral composition is shown in Table 2. Based on the details, charnockite sample consists 71 peaks, among the peaks, 28 peaks reported for microcline, the remaining 43 peaks were shared with olivine (18 peaks), hornblende (15 peaks), biotite (7 peaks) and hypersthene (3 peaks) respectively.

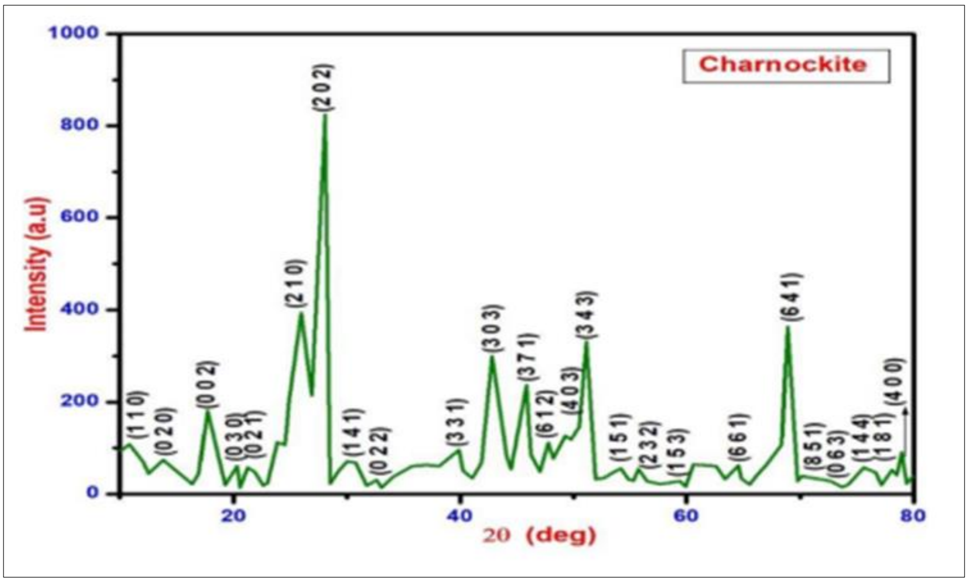

Figure 6 The XRD pattern of charnockite rock sample.

All the observed characteristic peaks (planes) are tabulated. From the table, all the major and minor peaks are well matched with the charnockite mineral composition of JCPDS No: 87-1792, and 85-1682. This indicates that the sample is in the form of charnockite. The pattern indicates that the intensity of the microcline plane is high compared with other minerals. It clearly shows the presence of large propositions of microcline in charnockite rock. Some low-intensity peaks represent the minerals in trace levels in charnockite. The mineral composition of charnockite is composed of microcline, hornblende, olivine, biotite and hypersthene. Microcline is rich in charnockite may be due to the rich composition of K which is rich in the magma during crystallization. Because microcline is a type of potash feldspar.

Table 2 XRD peak value details of charnockite rock

2theta[º]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM	Hklvalue	Size (nm)	Phase Name	JCPDS File NO.
10.85	8.1460	107.59	17.64	1.3345	1 1 0	6.255584	Hornblende	87-0611
12.12	7.2977	68.27	15.72	1.8734	1 0 0	4.451147	Microcline	87-1792
13.84	6.3952	74.03	11.84	1.3018	0 2 0	6.394647	Microcline	87-1792
17.66	5.0170	180.46	5.35	0.2411	0 0 2	34.36853	Olivine	85-1682
19.26	4.6044	19.25	0.57	0.2411	1 3 0	34.29064	Hornblende	87-0611
20.29	4.3740	61.03	1.81	0.2411	1 1 0	34.23696	Biotite	88-2200
20.53	4.3232	13.74	0.41	0.2411	0 3 0	34.22405	Microcline	87-1792
21.25	4.1776	57.41	1.70	0.2411	0 2 1	34.18443	Biotite	88-2200
21.88	4.0582	47.70	1.41	0.2411	2 0 1	34.14866	Hornblende	87-0611
22.61	3.9300	18.36	0.54	0.2411	1 1 0	34.10592	Microcline	87-1792
23.00	3.8639	23.72	0.70	0.2411	2 1 1	34.08251	Microcline	87-1792
23.84	3.7290	112.08	3.32	0.2411	1 1 1	34.03077	Microcline	87-1792
24.51	3.6296	107.15	3.17	0.2411	1 3 0	33.98818	Microcline	87-1792
24.90	3.5733	207.44	6.15	0.2411	1 3 1	33.96286	Microcline	87-1792
25.95	3.4304	393.59	11.66	0.2411	2 1 0	33.89273	Microcline	87-1792
26.92	3.3097	214.75	12.73	0.4822	1 2 1	16.91271	Microcline	87-1792
28.09	3.1738	824.27	24.42	0.2411	2 02	33.74099	Microcline	87-1792
29.27	3.0489	49.85	2.22	0.3617	2 1 2	22.43176	Microcline	87-1792
29.99	2.9770	70.19	3.64	0.4220	1 2 2	19.19454	Microcline	87-1792
30.74	2.9058	67.94	11.57	1.3864	1 4 1	5.83217	Microcline	87-1792
31.77	2.8143	17.87	1.06	0.4822	0 2 2	16.72629	Microcline	87-1792
32.61	2.7434	30.26	0.90	0.2411	1 82	33.38189	Microcline	87-1792
33.07	2.7069	13.76	0.51	0.3014	0 2 3	26.67173	Biotite	88-2200
34.06	2.6301	36.59	1.63	0.3617	1 1 2	22.16738	Hornblende	87-0611
35.78	2.5077	60.72	6.30	0.8439	2 0 2	9.456306	Biotite	88-2200
37.04	2.4248	62.43	2.31	0.3014	4 0 1	26.38145	Hornblende	87-0611
38.16	2.3565	60.79	2.25	0.3014	1 4 2	26.29382	Microcline	87-1792
39.91	2.2572	95.43	3.53	0.3014	1 1 3	26.15187	Microcline	87-1792
40.27	2.2377	49.48	5.86	0.9645	3 3 1	8.162927	Microcline	87-1792
41.05	2.1968	34.86	1.81	0.4220	2 5 1	18.60974	Microcline	87-1792
41.87	2.1560	67.61	9.01	1.0850	3 3 2	7.2185	Microcline	87-1792
42.83	2.1096	300.12	11.12	0.3014	3 0 3	25.90145	Microcline	87-1792
44.10	2.0520	80.84	3.59	0.3617	1 3 2	21.48821	Olivine	85-1682
44.52	2.0335	54.51	2.02	0.3014	1 6 0	25.74882	Microcline	88-2376

45.84	1.9777	236.46	8.76	0.3014	3 7 1	25.62571	Hornblende	87-0611
46.24	1.9619	85.72	9.52	0.9042	2 0 2	8.529243	Microcline	87-1792
47.19	1.9310	48.52	6.11	1.0248	6 1 2	7.498614	Hypersthene	76-0490
48.20	1.8866	77.35	2.86	0.3014	8 2 1	25.39714	Biotite	88-2200
49.31	1.8465	126.36	5.62	0.3617	4 0 3	21.07042	Microcline	87-1792
50.52	1.8052	146.18	4.33	0.2411	3 3 1	31.45504	Microcline	87-1792
51.12	1.7853	331.59	10.26	0.2517	3 4 3	30.0555	Microcline	87-1792
51.93	1.7593	31.82	4.25	1.0867	0 6 2	6.937707	Microcline	87-1792
52.72	1.7349	34.19	6.23	1.4828	1 1 5	5.067249	Biotite	88-2200
53.59	1.7087	47.97	2.88	0.4893	0 6 0	15.29784	Olivine	85-1682
54.19	1.6911	55.02	1.23	0.1816	1 51	41.10868	Olivine	85-1682
54.86	1.6722	30.75	0.70	0.1848	1 3 5	40.27531	Olivine	85-1682
55.31	1.6596	29.21	0.35	0.0965	0 6 1	76.97047	Olivine	85-1682
55.76	1.6472	54.62	1.62	0.2411	2 3 2	30.74371	Hypersthene	76-0490
57.06	1.6128	24.38	0.72	0.2411	1 51	30.55722	Biotite	88-2200
57.66	1.5974	21.23	0.47	0.1808	1 1 3	40.63205	Hornblende	87-0611
59.41	1.5545	28.14	0.63	0.1808	1 5 3	40.28577	Hornblende	87-0611
59.89	1.5431	16.48	0.37	0.1808	3 0 1	40.18914	Olivine	85-1682
60.58	1.5271	64.18	2.38	0.3014	3 1 1	24.02409	Olivine	85-1682
62.57	1.4833	60.50	2.24	0.3014	2 0 3	23.77679	Hornblende	87-0611
63.39	1.4662	31.85	1.65	0.4220	2 10 2	16.90753	Hornblende	87-0611
64.59	1.4417	61.54	2.74	0.3617	3 3 0	19.5976	Olivine	85-1682
64.86	1.4363	33.49	2.48	0.6028	6 6 1	11.74166	Hornblende	87-0611
65.59	1.4222	20.16	0.60	0.2411	1 1 4	29.23718	Olivine	85-1682
66.10	1.4124	36.83	1.09	0.2411	6 0 1	29.15305	Hornblende	87-0611
67.09	1.3939	63.52	1.88	0.2411	2 5 3	28.98809	Olivine	85-1682
68.39	1.3706	107.12	7.14	0.5425	7 3 1	12.78527	Hornblende	87-0611
68.90	1.3616	363.83	13.48	0.3014	1 7 3	22.94282	Hornblende	87-0611
69.72	1.3477	28.18	1.25	0.3617	6 4 1	19.02362	Hornblende	87-0611
70.14	1.3406	38.58	1.43	0.3014	8 5 1	22.77117	Hypersthene	76-0490
72.64	1.3005	28.35	0.63	0.1808	0 6 3	37.36997	Olivine	85-1682
74.24	1.2764	19.98	0.59	0.2411	1 7 2	27.73324	Olivine	85-1682
75.62	1.2564	57.10	2.11	0.3014	1 4 4	21.98095	Olivine	85-1682
75.62	1.2564	57.10	2.11	0.3014	1 4 4	21.98095	Olivine	85-1682
76.68	1.2418	46.96	1.74	0.3014	3 1 3	21.82223	Olivine	85-1682
78.09	1.2227	51.50	2.67	0.4220	1 8 1	15.43298	Olivine	85-1682
78.49	1.2176	40.57	1.20	0.2411	3 2 3	26.93588	Olivine	85-1682
80.02	1.1981	39.83	1.18	0.2411	4 0 0	26.6397	Olivine	85-1682

3.5. Microstructures

Rock samples from the study area were applied to examine the microstructure. Based on the images obtained from the petrographic microscope images combined with the Scanning Electron Microscope (SEM).

3.5.1. Dolerite

The observed microstructures (Fig. 7) are in three types; micro cracks–intra-granular, intergranular and transgranular. The micro-cracks are seen through SEM images showing alternating wedges of the augite and labradorite grain boundary (Olivine). Curved ends of two augite wedges are encircled (white dashed line). The impact generated microfractures in the augite wedge cease in the adjacent labradorite wedges. The grains adjacent to the augite and labradorite do not have wedges is similar to cases where multiple PF sets are produced in a particular grain, while the surrounding grains are left undeformed [19, 20, 21]. The microfractures were filled possibly with the labradorite from the adjacent wedge. The bulk labradorite contains sharp spots and diffused background. The labradorite in bulk crystal demonstrated perfectly aligned, well-developed lattice planes and the absence of amorphous components. The granite's compositional variability, which represents the rapid termination of the anatectic processes and the modification of the P-T conditions, is related to a shift from a compressional to an extensional tectonic setting extension regime [22].

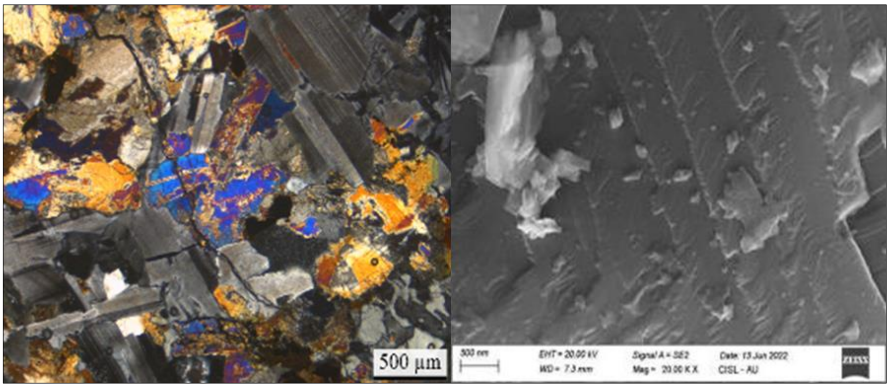

Figure 7 Microstructures of dolerite rock.

Compositionally, dolerite is characterized by a combination of quartz, augite, and plagioclase feldspar [23]. In order to confirm the form of [SiO_2-$NaAlSi_3O_8$-$Al_2Si_2O_8$-(Ca, Na) (Fe, Mg, Al-Ti) (Si, Al_2O_6)] EDAX analysis was performed. During EDAX measurement, different areas were focused and the corresponding peaks (Figure 8). The chemical composition elements can be seen in sample No.1 in the EDAX peak spectrum. In peak spectrum, the quantity of carbon 18.35%, oxygen 65.31%, sodium 0.95%, Aluminium 0.50%, silica 7.34%, calcium 1.96%, chromium 0.08%, promethium 0.1% is measured in atomic weight respectively. In the given data, the oxygen percentage is higher when compared to other elements followed by silica. So, in this case, quartz (SiO_2) is rich in the given rock sample. Promethium is a chemical element with the symbol Pm. Its isotopes are radioactive element which is present in the specimen. The dolerite elemental percentage detected from FESEM-EDAX is shown in Table 3.

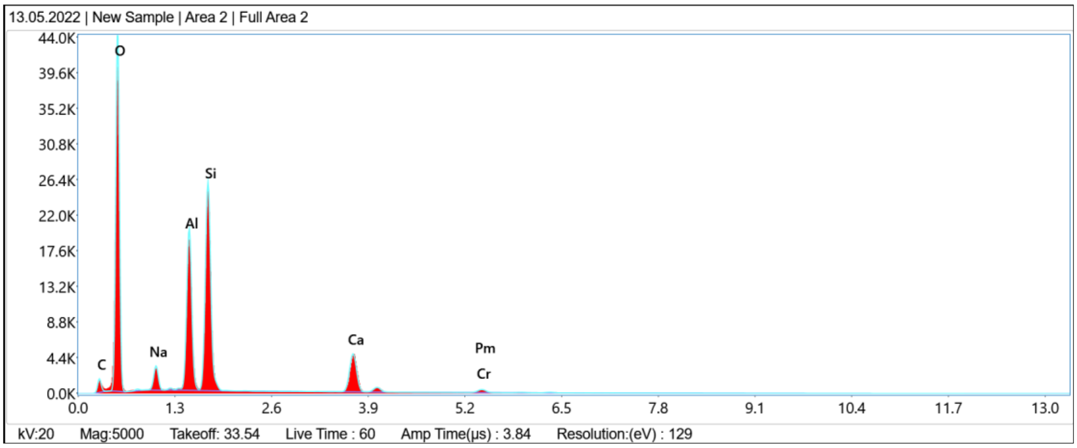

Figure 8 EDAX measurement dolerite.

Table 3 The dolerite elemental percentage detected from FESEM-EDAX

Element	Weight%	MDL	Atomic%	Error%	Net Int.	R	A	F
CK	12.58	0.3	18.35	12.06	133.17	0.9113	0.0542	1.0000
OK	59.65	0.07	65.31	9.62	4391.71	0.9215	0.1475	1.0000
NaK	1.25	0.11	0.95	10.99	157.67	0.9330	0.2369	1.0043
AlK	9.08	0.03	5.90	6.24	2628.03	0.9397	0.5035	1.0081
SiK	11.76	0.02	7.34	5.65	3576.23	0.9428	0.5571	1.0043
CaK	4.49	0.04	1.96	2.83	882.04	0.9586	0.9032	1.0204
CrK	0.24	0.09	0.08	12.26	32.60	0.9674	0.9602	1.0551
PmL	0.95	0.21	0.11	18.46	48.84	0.9703	0.9664	1.0134

3.5.2. Charnockite

The charnockite collected from the Yellikkaradu study area was studied under petrographic and SEM. The image (Figure 9) displaces an interconnection of two sets of perpendicular micro-cracks in the pyroxene grain; because they are the cleavage micro cracks. These micro-cracks show a constant pattern forming a circular area around a small area of a homogeneous microstructure. In the thin section image, there is a presence of the interpenetration of grain boundaries.

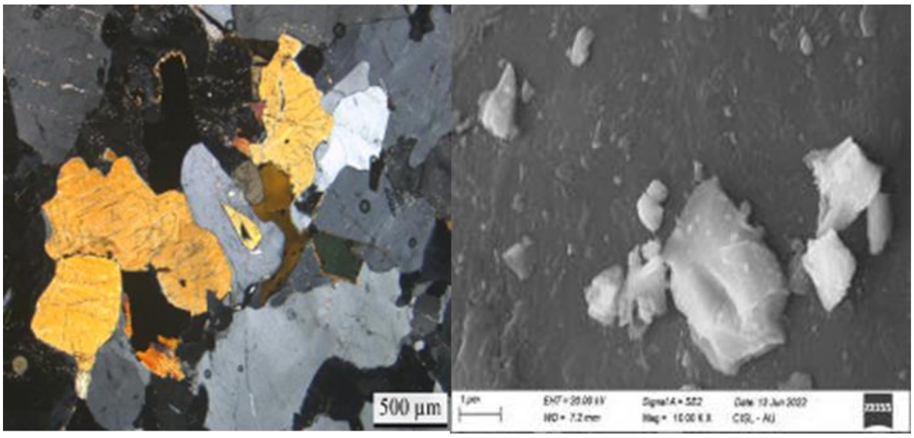

Figure 9 Microstructures of charnockite rock.

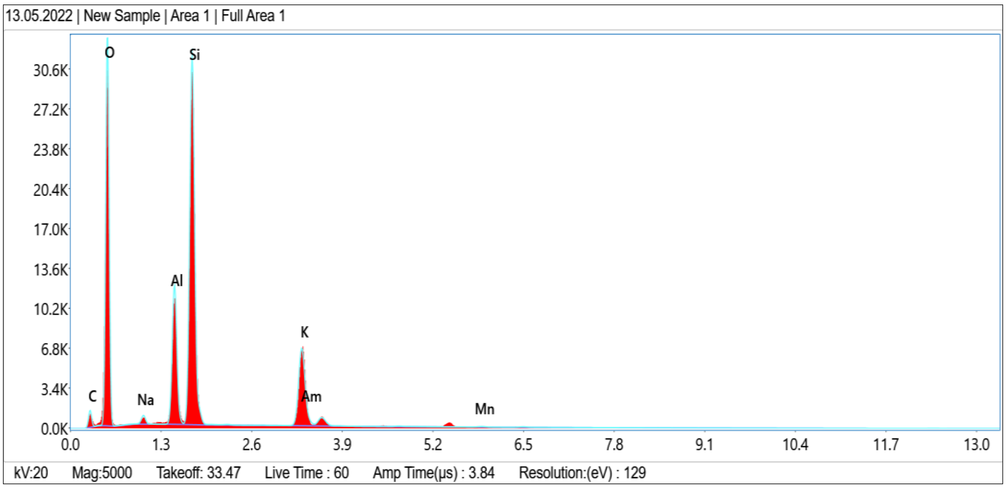

Figure 10 EDAX measurement peaks of charnockite rock.

Table 4 The charnockite elemental percentage detected from FESEM-EDAX

Element	Weight%	MDL	Atomic%	Error%	Net Int	R	A	F
CK	13.35	0.3	19.68	12.10	118.10	0.9095	0.0528	1.0000
OK	56.80	0.07	62.86	9.78	3310.95	0.9197	0.1360	1.0000
NaK	0.75	0.06	0.58	11.96	82.40	0.9314	0.2397	1.0040
AlK	6.14	0.03	4.03	6.23	1566.90	0.9383	0.5167	1.0097
SiK	15.85	0.03	9.99	5.31	4384.72	0.9414	0.5901	1.0046
KK	6.11	0.04	2.77	3.03	1181.44	0.9551	0.8673	1.0144
MnK	0.12	0.07	0.04	25.58	11.46	0.9687	0.9656	1.0663
AmM	0.89	0.2	0.06	13.87	66.41	0.9578	0.8760	1.0058

Compositionally, charnockite is characterized by a combination of quartz, hypersthene, microcline, hornblende, olivine, and biotite. To confirm the form of [SiO_2-$KAlSi_3O_8$-$(Ca, Na)_2$ $(Mg, Fe, Al)_5$ $(Al, Si)_8$ $MgFe^{2+}$(Mg, Fe) (Al, Si)O (F, OH)] EDAX analysis was performed. During EDAX measurement different areas were focused and the corresponding peaks were shown in Figure 10. The chemical composition elements can be seen in the sample in the EDAX peak spectrum. In the peak spectrum, the quantity of carbon 19.68%, oxygen 62.86%, sodium 0.58%, aluminium 4.03%, silica 9.99%, calcium 2.77%, potassium 2.77%, manganese 0.04%, americium 0.06% is measured in atomic weight respectively. In the given data the peak value of Si and O is higher. So, in this case, quartz (SiO_2) is rich in the given rock sample. Manganese is present in this rock. Americium is a chemical element with the symbol Am. It is an isotope radioactive element present in the specimen. The charnockite elemental percentage detected from FESEM-EDAX is shown in Table 4.

4. Conclusion

Both the samples (dolerite and charnockite) exhibit a sub-ophitic texture based on petrographic analysis, and the mineral assemblages of the XRD measurement reveal that plagioclase feldspar, augite, and quartz as an essential minerals. The intergrowth granophyric texture firmly demonstrates the intrusion of the youngest magma with older rock. The oldest Archean granulitic rocks were formed in that terrain with structural disturbances such as faults, joints, etc.,. Later, due to late magmatism, the lava is emplaced in that structures. The mineral percentage of quartz is rich in the rocks because of intergrowth texture and the cooling temperature and pressure of the rocks are low so the magma crystallized rapidly above the surface. Hence, the crystallizing temperature of the quartz is low. Thus, the rocks contain a significant proportion of quartz. Thus, it is a quartz-dolerite rock.

Compliance with ethical standards

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Disclosure of conflict of interest

We don’t have any conflict of interest in publishing the paper.

References

[1] Armstrong R.L. and Besanon J. A Triassic time scale dilemma, K-Ar dating of upper Triassic mafic igneous rocks of eastern U.S.A and Canada and post upper Triassic plutons, Western Idaboo, U.S.A Eclogae Geol. Helv. 1970; (63):15-38.

[2] Boer J.de. Paleomagnetic-tectonic study of Mesozoic dyke swarms in the Appalachians J. Geophys. Res. 1967; (72):2237-2250.

[3] Bryan S. E. and Ernst R. E. Revised definition of Large Igneous Provinces (LIPs). Earth Sci. Rev. 2008; (86):175-202.

[4] Rao V.D., Rao P.R. and Rao M. S. The Ghingee Granite, Tamil Nadu, South India. Geochemistry and Petrogenesis. Gondwana Research. 1999; (1):117-26.

[5] Don Herms O. L. A quantitative petrographic study of Dolerite in the deep river basin of North Carolina. Journal of Earth and Planetary Materials. 1964; (11-12):1718-29.

[6] Ernst R.E and Buchan K.L. Large mafic magmatic events through time and links to mantle-plume heads. Mantle Plumes their identification through Time. Geological Society of America (2001); 352, 483–575.

[7] Foley S.F., Venturelli G., Green D.H., and Toscani L. The ultra potassic rocks characteristics, classification, and constraints for petrogenetic models. Earth-Science Reviews. 1987; (24):81–134.

[8] French B. M., Kocberl C., Gilmour I., Shiery S. B., Dons J.A., and Naterstad J. The Gardnos impact structure, Norway. Petrology and geochemistry of target rocks and impactits. Geochemica et Cosmochimica Acta.1997; Issue 4, p. 873-904. DOI: 10.1016/S0016-7037(96)00382-1

[9] French B. M., Cordua W. S., and Plescia J. B. The rock El meteorite impact structure, Wisconsin: Geology and shock-metamorphic effects in quartz. Geological Society of America Bulletin. 2004; 116(1-2):200-218.

[10] Halls H.C. The importance and potential of mafic dyke swarms in studies of geodynamic processes. Geoscience Canada. 1982; (9):145–154.

[11] Hou G.T., Santosh M., Qian X.L., Lister G.S. and Li J.H. Configuration of the Late Paleoproterozoic supercontinent Columbia. Insights from radiating mafic dyke swarms. Gondwana Research. (2008); (14):395–409. DOI:10.1016/j. gr.2008.01.010.

[12] Justus, P.S. Modal and textural zonation of diabase dykes, Deep River Basin, North Carolina. [M.Sc. Dissertation]. University of North Carolina; 1966.

[13] Kieffer. Shock metamorphism of the Coconino sandstone at meteor crater, Arizone. Journal of Geophysical research. 1971; (76):5449-473.

[14] King, P.B. Systematic pattern Survey of Triassic dykes in the Appalachian region. U. S. Geol. Professional papers. 1961; 424-B, B93-B95.

[15] Lawrence, D.E. A contribution to the petrology of the Great Dyke of Nova-Scotia. M.Sc. Thesis, Dalhousie University, 108 p. (1966).

[16] Le Cheminant A.N, and Heaman L.M. Mackenzie. Igneous events, Canada Middle Proterozoic hotspot magmatism associated with ocean opening. Earth Planet. Sci. Lett. 1989; (96):38-48.

[17] Liu S., Zou H.B., Hu R.Z., Zhao J.H. and Feng C. X. Mesozoic mafic dykes from the Shandong Peninsula, North China Craton. Petrogenes is and tectonic implications. Geochemical Journal. 2006; (40):181–195. DOI:10.2343/geochem J.40.181.

[18] Marsh J.S. Geochemical constraints on complied assimilation and fractional crystallization involving upper crustal compositions and continental theolitic magma. Earth planet. Sci. Lett. 1989; 92,70-80.

[19] Mathew Joseph. Geochemistry, petrogenesis and palaeomagnetism of the dyke swarms of Thiruvannamalai area, Tamil Nadu and the lithospheric processes-in South India. Seymour K.S and Kumarapلli, P.S (1995) Geochemistry of the Grenville dyke swarm: role of plume-source mantle in magma geneisis. Contrib Mineral., petrol., 120,29-41.

[20] Shrivastava V. S. X-ray Diffraction and Mineralogical Study Soil. A Review. J Appl. Chem. Res. 2009; (9): 41–51.

[21] Steele, K. F, Ragland PC. Model for the closed system Fractionation of a Dyke formed by two pulses of Dolerite Magma. Conrtibutions to Minerology and Petrology. 1976; 57(3):305-316.

[22] Steffer D and Langerhorst F. Shock metamorphism of quartz in nature and experimental. Basic observation and theory meteorites. 1994; (2):115-181.

[23] Zhao J.X., and McCulloch M.T. Melting of a subduction-modified continental lithospheric mantle. Evidence from Late Proterozoic mafic dyke swarms in central Australia: Geology. 1993; (21):463–466.