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RESEARCH ARTICLE

GEOLOGICAL SETTING OF THE BLACK GRANITE DEPOSITS (MAFIC DYKES) IN THE PARTS OF VILLUPURAM DISTRICT, SOUTHERN GRANULITIC TERRAIN, TAMILNADU, INDIA

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ABSTRACT

The study area forms the part of the Southern Granulitic terrain of the peninsular India. It is represented by charnockites and gneisses. These terrain was found intersected by the younger mafic dykes commonly known as Black granites. The economic importance and its massive nature of the rock brought name and fame to the locality all over the world. Based on the nature of the trend these dyke bodies were characterized into three groups namely Group – I, Dykes having trends NW-SE, WNW-ESE and E-W. Group – II, Dykes having trends NNW-SSE, N-S and NNE-SSW. Group –III, Dykes having trends NE-SW. Based on mineralogical composition they can be classified into two types namely dolerite and gabbro. These bodies are medium to coarse grained in nature with fine grained border zone at the contact with the country rocks. These dyke bodies exhibits typical spheroidal weathering. The rocks are essentially composed of plagioclase, clinopyroxene and opaques. Olivine and micro perthite constitute the accessory mineral phases while minor biotite, amphibole and quartz rarely occur as secondary components. All the samples exhibit ophitic to sub ophitic intergrowth of plagioclase and pyroxene.

INTRODUCTION

The area under Geological study falls in the Villupuram district of Tamilnadu. It forms a part of the Southern Granulitic Terrain(SGT). Villupuram District lies between 11° 38' 25" N and 12° 20' 44" S: 78° 15' 00" W and 79° 42' 55" E. The present study deals with the occurrence of the mafic dykes (Black granite deposites) found in the district, as this region was once well known for its Black granite deposits all over the world. The mode of occurrence and the nature of emplacement of these mafic dykes plays significant role in the younger intrusive activities in the SGT. The location map of the study area are given in Figure 1.

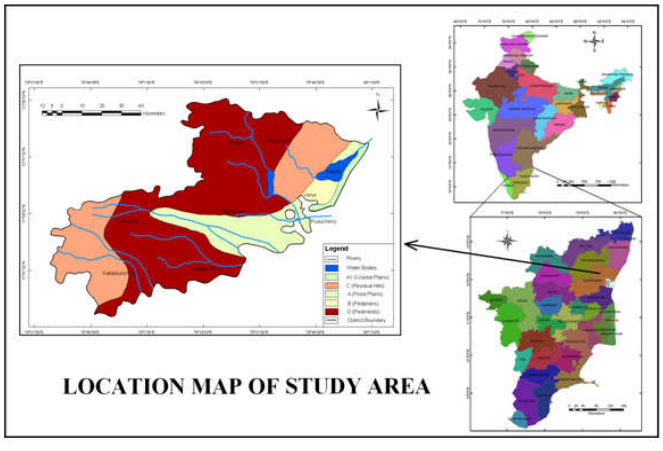

Fig.1 Location map of the study area Villupuram district showing its various geomorphic features.

Topography

From less than 20 meters from M.S.L elevation in the eastern extremity of Toposheet 57 P/12, the topography gradually rises to a maximum of 566 meters in the Pakkam malai Reserve forest on the western extremity of toposheet 57 P/8. From the vast stretch of peneplain on the eastern side. The morphology changes to pediplain in the central parts and to a hilly terrain on the western side. In the peneplain area, presence of dykes is marked by boulders, scattered in a crude linear fashion. Stray outcrops appear to be exhumed humps of dyke bodies. In the pediplain and hilly regions dykes occur in distinct outcrop and bands respectively. Bed rocks or the country rocks in study area generally charnockite and gneissic granites. Most parts of the district are covered by a flat plain sloping gently from north to south and from west to east towards the sea. The only hills in it are the Kalrayan on the southwest border, the Gingee hills to the southwest of Gingee. The mount capper hill near Cuddalore and the Red hills to the west of Puducherry.

The rivers of the district, almost all of them, flow towards the east into the Bay of Bengal. Going from the north to the south, the Ongur and the Kodamu are 2 small streams formed by the surplus waters of 2 chains of tanks in the Tindivanam taluk. Both of them fall into the Kaliveli swamp in the same taluk. The Gingee River also called as the Sankarabharani River or the Varahanadi originates in the Gingee taluk & flows past Gingee in a southerly course into the Villupuram taluk.

Regional Geological framework of Southern Granulitic Terrain (SGT)

The southern Indian shield has been traditionally divided into the Dharwar Craton and Southern Granulitic Terrain(SGT), following the classification by Fermor (1936) into charnockitic and non –charnockitic provinces. It is generally held that the southern Indian shield is a composite continental segment, formed by the accretion of various crustal blocks during the mid –Archaean to neoproterozoic (Radhakrishna, 1989; Harrus *et al*., 1994; Jayanandha and Peucat, 1996). However a unitary model of one continent dissected by steep faults has also been proposed (Mahadevan, 1998), consistent with earlier concepts of Fermor (1936). Based on geochronology and isotope data different age provinces with distinct precrustal histories are proposed within the composite unit of Southern Indian Shield (Harris *et al*., 1994) Bartlet *et al*, 1995. Jayananda *et al*.1995; Santosh *et al*.. 2003. Cenki *et al., 2004*. Regional geological framework map of the Southern Granulitic terrain is shown in Fig. 2.

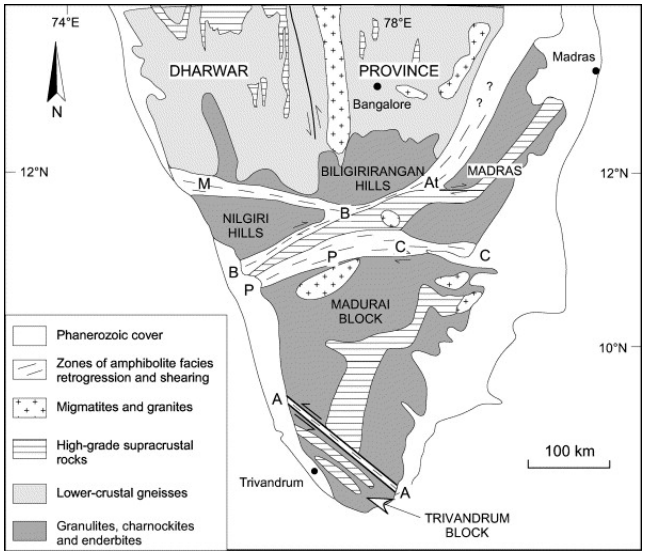

Fig.2.Regional tectonic map of SGT (After Meissner *et al.,* 2002)

Geological setting of the Black Granites (mafic dykes) of Villupuram District

Most part of the Villupuram district is covered by the charnockitic rocks and the migmatite complex. In the western part of the Kallakurichi most of the region is occupied by the charnockitic group of rocks viz. charnockite, pyroxene granulite and garnetiferous gabbro. Eastern part of this area is made up of Hornblende-biotite gneiss, pink augen gneiss and pink migmatites with younger intrusions of Tindivanam and Gingee Granites. Doleritic mafic dykes forms the youngest intrusive traversing both charnockites as well as the migmatites. The entire District is found intruded by the dyke swarms. Their trend varies from place to place and from region to region. Primarily these dyke swarms can be broadly grouped into three sets based on their nature of trend:

Group – I	Dykes having trends NW-SE, WNW-ESE and E-W.
Group – II	Dykes having trends NNW-SSE, N-S and NNE-SSW.
Group –III	Dykes having trends NE-SW.

Apart from their distinct orientation, dykes of the different group do not exhibit any mutual relationship and where there is an intersection of two dykes, the point of intersection is either concealed under soil cover or extremely sheared thereby not giving any idea on their mutual and genetic relationship. But at some places the genetic relationship can be established. On the basis of the mineralogical composition, the dyke bodies can be broadly classified into two categories:

1. Doleritic dykes
2. Gabbroic dykes.

The dyke swarms of the Villupuram district is shown in Fig. 3

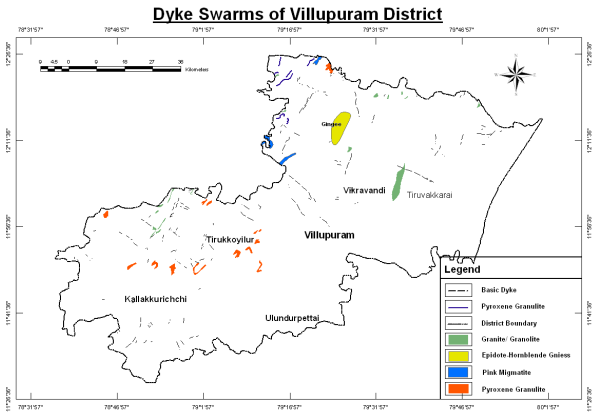

Figure 3. Dyke swarm map of Villupuram District

Group – I Dykes

Among the three groups, group – I is well exposed and the frequency of occurrence is more, in longer linear dimensions and from commercially viable deposits for quarrying operation. They vary in aggregate length from less than a kilometer to more than 20 km. and their width varies from less than 3m to 60m at some places with Mean width 30m and the mode is 20m. They are dismembered at frequent intervals and hence do not constitute a continuous stretch of a body. As the dykes occur in distinct linear extensions as more or less parallel bodies, they are treated as individual belts, named after local villages.

Kunnam – Mailam Belt

Kunnam –Mailam belt covers an area of about 15 km^2 from Semangalam in southeast to chendur in northwest, here emerge a pair of parallel dykes over a length of about 12.5km. Futher southeast of Semangalam sedimentaries overlie the dykes and in the northwest part, after Chendur the dyke belt abruptly ends in the vicinity of Tondi – Varahanadi Rivers. It is significant to note that Tondi River and Varahanadi further west act as barriers for further continuation of this belt. The rivers probably occupy the NNW-SSE fault planes by which the northwestern continuity of the dyke belt is severed and there exists a vast alluvial plain to a distance of about 32km in its trend. The inference of faults along Tondi River – Varahanadi is further strengthened by the field observation at Mailam, wherein there is a minor quartzite ridge trending N-S and at the southern end the Kunnam Mailam dyke swerves around the ridge and takes a trend its WNW-ESE. Quartzite is intensely sheared with profuse development of garnet. The two parallel dykes which emerge from the western side of Semangalam are disposed about 0.5km apart and in between

occupied by charnockite and run to a distance of about 10km, after which they merge and run as a single body to a further distance 5km. At the point of merger there is perceptible variation in the trend from WNW-ESE to E-W before it swerves back to its original trend. It is also to be noted that the quartzite ridge, mentioned earlier, lies just north of the site of the merging of the dyke bodies.

Fig. 4. Quarry of Black granite at Kunnam

Fig. 5. Quarry of Black granite under operation (Kunnam)

Fig.6. Doleritic dyke rock exhibiting spheroidal Weathering

Fig. 7. Extension of Kunnam dyke upto Mailam(Mailam temple in the background)

Fig.8. Exposed quarry of gabbro variety of Black Granite west of Tiruvakkarai temple

Fig.9. Exposed wall dyke near Tiruvakkarai

Petrographic studies of these area reveals that these dyke bodies are mostly medium to fine grained. At the contact zone in the field, the bodies show more fine grained nature. Pyroxene and feldspar are the major constituents exhibiting textures varying between ophitic, sub-ophitic, Doleritic and intersertal. Bodies of these locality is considered to be the best in the area and moreover once it was the world's top most demand because of its grain size and its colour (Selvaraj.B. 1992)

Ponnampundi – Tiruvakkarai Belt

A another set of fragmented dyke body with an aggregate length of about 1.5km occurs within charnockite between Tiruvakkarai in southeast and Ponnampundi in northwest. The southeastern end of the dyke is overlain by sedimentaries and northwestern part continues in parts up to Ponnampundi beyond which it is not exposed. Further northwest about 9km two fragmentary dyke bodies, on the western bank of Varahanadi, have a strike continuity with the Ponnampundi – Tiruvakkarai belt, they are found exposed at two different locations one at Sittani and the other is located a kilometer south of Perani. These are the only two pocket of dyke having trend NW-SE and occur close to the west bank of Varahanadi. Petrographic study of these dykes reveals them to be of Gabbroic dykes with mostly medium to fine grained nature. Compared to the Kunnam belt this belt is found to be of less dark in color. Joint patterns are more when compared to the previous one, but its massiveness enables to keep it in the market value. Similar to the Kunnam variety these blocks are also exported for Japanese and European monuments.

Nagalampattu – Pudur Belt

There is a NNW – SSE trending dyke in the area 1km west of Karuvakshi which probably swings to NW-SE forming the Nagalampattu – Pudur dyke extension. It is also possible that

the Karuvakshi dyke is entirely different which ends abruptly against the present belt. Transverse faults in orientations NNE-SSW and NE-SW are frequent and area wherein the faults have displaced dykes are

(i) Southeast of Pudur.
(ii) West of Pudur.
(iii) West of Palavalavu.
(iv) 1.5km east of Nagalampattu.

A major fault trending N30ºE – S30ºW accompanied with sympathetic shear and slip planes in the area 1.5km east of Nagalampattu has been traced.

Group -II Dykes

Elavampattu-Sirular Belt

The Elavampattu-Sirulur belt is confined between the two groups, namely Group III dykes (NE-SW) on the northern side and Group I (NW-SE) on the southern side. The N-S dyke does not continue beyond the intersection of the dykes of the two groups indicating probably its antiquity when composed to other sets. A group of dismembered dyke bodies were also having trend NNE-SSW and N-S occur in the intervening area between Malasur and Endiyur. At Kattalai, the dyke takes an accurate swing to NE-SW and then to ENE-WSW.

In between Ulagalampundi to Tuduppakkam a series of disconnected dyke bodies having trend common to this group occur over an area of about 100km^2 in the eastern extremity of toposheet 57 P/8. A dyke south of Ulagalampundi is intersected by the NW-SE (Group-I) set of dykes beyond which it does not continue. Another dyke occurring south of Tuduppakkam runs as a single body upto Kalladikuppam where it bifurcates, towards Ulagalampundi in the trending NNW-SSE and the other to Arasalapuram in the direction NNE-SSW.

A dyke running to a distance of about 4 kilometers occurs about a kilometer east of Pakkam. From a trend of N-S in the hill slopes of Pakkammalai Reserve Forest the body takes a swing to NNE-SSW in the plains. Petrographically they are medium to coarse grained with the occurrence of Olivine crystals. At Virapandi, a N-S dyke intersects the E-W dyke and continues further south which is an unusual phenomenon since elsewhere in the area the N-S dyke is abruptly terminated by E-W dyke and further continuity beyond intersection is a remote occurrence. Whereas here the intersection of the two different sets of dykes appears to be contemporary and this observation may throw some light on the evolutionary trend of dyke sets.

Group III Dykes

Occurrences of Group III dykes are sporadic confined to the following localities.

1. Kallakullattur-1.5 kilometers long.
2. A set parallel dykes (each about 500 meters in length) exposed in the Varahanadi River section at Sengamedu and further south.
3. Pettai- about a kilometer in length.

Outcrops of this group of dykes are boulder in nature and their exact relationship with the other two Outcrops groups of dykes is uniquitous. Occurrence of commercially viable deposits in this group of dykes is remote.

Geological structures of the Black granite of the study area (Mafic Dyke swarms)

Black granite deposits of the area have undergone regional deformation along with the host rocks. The most common feature in dyke sets having any type of landform is undulation. A series of humps and basins occur predominantly in the two dimensional length and width. The development of this complex topography is mainly due to more than one generation of folding. The amplitude and the wavelength of undulation vary extremely. For example, in case of dyke occurring at Kunnam in a total span width of about 60 meters, two humps having outcrop width of 15 meters were exposed with an interval of 25meters, in between basin has a soil overburden of 12 to 15 meters as a result of which the economy of quarrying goes above the limit. Faults are quite common, clear cut evidences of faulting such as slickenside, displacements are not found in exposures. Some are genuine faults; others are simple shifts along pre existing fractures and joints without affecting any appreciable effects on the dyke body.

Joints are common in the dykes and it is their density of occurrence and spacing between them at any one particular area render the deposit either viable or unviable for commercial exploitation. Among joints of varying orientations the predominant are N 40°E -S40°W and N45°W-S45°E followed by N-S and E-W. Mutual intersection of these joints along with horizontal joints gave rise to boulders of varying angularity and depending upon spacing and dip, size of boulders vary from diameter less than 50 cm to more than 500 cm. Contact margins with the host plays vital role in designing the quality of the granite material. In majority of cases, dykes have sharp, well defined contact with the host rock, exhibiting chilled margin. In some of the cases the contact looks diffuse with profound intermingling and assimilation of host and the dyke rocks. At places the contact is marked by intense shearing with large scale development of fractures and venation both within dyke and the host rock. From field observations it is evident that the emplacement of dykes had taken place in all the phases of tectonism pre, syn and post.

Conclusion

Mafic dyke bodies are commonly known as Black granites are the essential and economically important to the Villupuram district of Tamilnadu. These dyke bodies are medium to coarse grained dolerites and gabbros. These bodies exhibit typical characteristics of intrusive body with fine grained nature in the contact zone with medium grained nature in the core zone. The rocks are essentially composed of plagioclase, clinopyroxene and opaques. Olivine and micro perthite constitute the accessory mineral phases while minor biotite, amphibole and quartz rarely occur as secondary components. All the samples exhibit ophitic to sub ophitic intergrowth of plagioclase and pyroxene.

In the present study it is tried to describe in elaborate the geological field setting of the Black granite deposits (mafic dykes) of the Villupuram district. As these intrusive forms one of the latest igneous activity in the region thus supplementing the crustal building activity of the region.

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