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PETROLOGICAL AND PETROCHEMICAL STUDIES OF ULTRAMAFIC ROCKS IN AND AROUND AYYAMPALAIYAM AREA, METTUPALAIYAM ULTRAMAFIC COMPLEX, TAMILNADU WITH SPECIAL REFERENCE TO PGE MINERALIZATION

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Abstract:

This area has been named with reference to this nearest village and named as 'A' area for convenience to report writing and presentation. In this area 12.25 lkm traverses were taken along and across the strike and dip of the formation. Based on mineralogical variation 28 chip/groove samples were taken. The general trend of the formation is N 80° E to S 80° W with northernly dipping sub-vertically. Collected samples for numbered APM-1/12 to APM-25/12 (APM = Ayyampalaiyam). Also collected samples at different locations showing in geological traverse line & sample location map of Ayyamplaliyam area. Three detached talc tremolite actinolite bands are present with pinching and swelling nature from west to eastern directions. This area has been divided into three segments such as eastern, central and western. These talc tremolite actinolite bands are inter-banded with meta gabbros and cobanded with banded magnetite quartzite. The interbanded with gabbroic anorthosite / anorthositic gabbros in the western part. In eastern part, the meta-pyroxenite is co-banded with fuchsite quartzite and interbanded with meta-gabbros. The central segments is consists of only one talc tremolite actinolite schist band. This band strike length is 6 km over the width of 20-30m. The western segment is consist two meta talc tremolite-actinolite schist rock are exposed. These two meta ultramafic bands are traceable more than 2 km from east to west. The western ends of the talc tremolite bands are traceable in the north of Peddikuttai village.

Key Words: Ayyampalaiyam**,** PGE, Petrological, Anorthositic & Banded Magnetite Quartzite

Introduction:

Chetty (1996) suggests that the major shear system in southern granulite terrain trends in EW and NE-SW directions. The Cauvery shear zone has been broadly divided into eastern and western parts separated by the centrally located Sankaridurg granite dome. The western part of the zone consists of Moyar shear zone, Bhavani shear zone and Palghat shear zone. The eastern part includes Salem-Attur shear zone, Cauvery shear zone and Gangavalli shear zone. Achankoil shear zone lies in the southern area of southern granulite terrain.The study area forms a part of Southern Indian Peninsula. The Precambrian shield of South India, which forms a coherent crustal segment with continuous geological activity throughout the early Precambrian, offers an excellent ground for the study of Mafic–Ultramafic formations for PGE analysis. Gabbroic rocks grade into anorthosite and pyroxenite with increasing plagioclase and pyroxene respectively. Leucogabbros and melanogabbrosgradation have been observed in field of Ayyampalaiyam area. Garnet grains have been observed occurring as concentrated in the margins of gabbro / gabbroic bodies. The ultramafic rocks are inter-banded with meta-gabbro. The general trend of the rock is ENE –WSW with steep (75°-85°) dip towards south. The Metapyroxenites occur as detached and discontinuous bands (pinching and swelling).

Study Area:

It is bounded between the north latitude 11° 22'30" – 11° 25' 00" and east longitude 77° 02' 30" – 77° 07' 30" named with reference to nearest village. In this area8 l.km traverse was taken along and across the strike and dip of the formation. Based on mineralogical variation 20 chip/groove samples were collected. The general trend of the formation is N 80° E to S 80° W with northerly dipping subvertically. Three detached talc tremolite-actinolite bands are exposed in the area which showpinching and swelling from west to east. This area has been divided into two segments such as eastern segment and western segment. The western segment shows talc-tremolite-actinolite bands which are inter banded with meta gabbros, magnetite quartzite and gabbroic anorthosite / anorthositicgabbroswhereas, in the eastern part, the meta-pyroxenite is co-banded with fuchsite quartzite and meta-gabbros. A total number of 8 samples have been collected. In the eastern part of southern band is analysed by the previous workers of PGE value is sample No. APT/4 (144Pt + 487 Pd over 0.50m width.The western segment consists of meta talc-tremolite-actinolite schist.Two meta ultramafic bands are traceable for more than 2 km from east to west. Western end of the talc tremolite bands are traceable in the north of Pedikuttai village.

Geological Map of Tamil Nadu Showing the Location of Mettuppalaiyam Mafic –Ultramafic Complex:

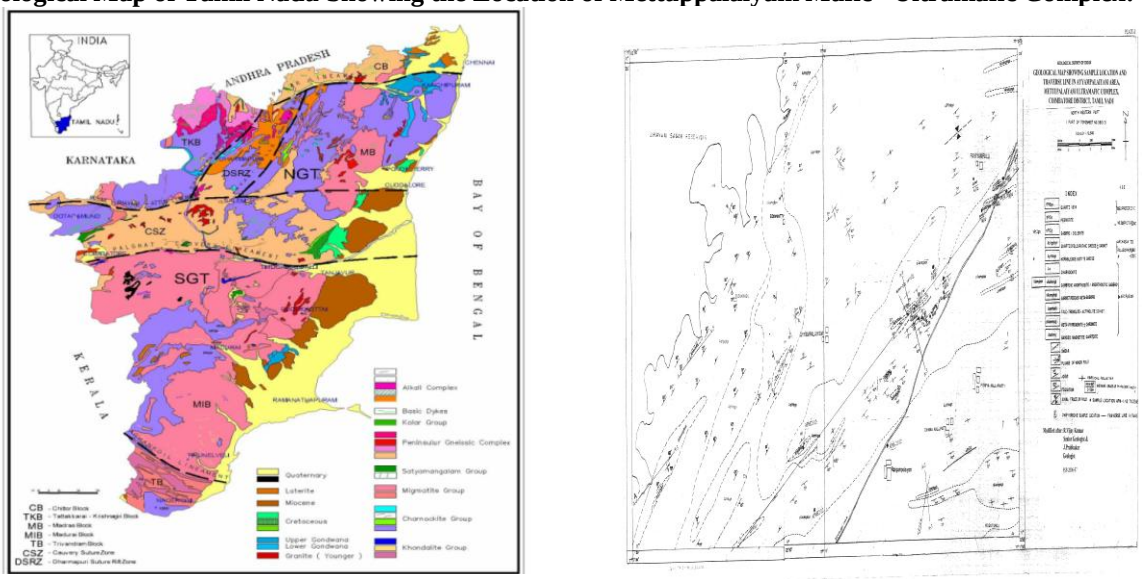


Figure 1: Study Area

Methodology:

Field Techniques and Sampling:

A systematic geological mapping was carried out on a scale 1: 50 000 with the survey of India Toposheet as the base. The geological mapping generally proceeded in five stages.

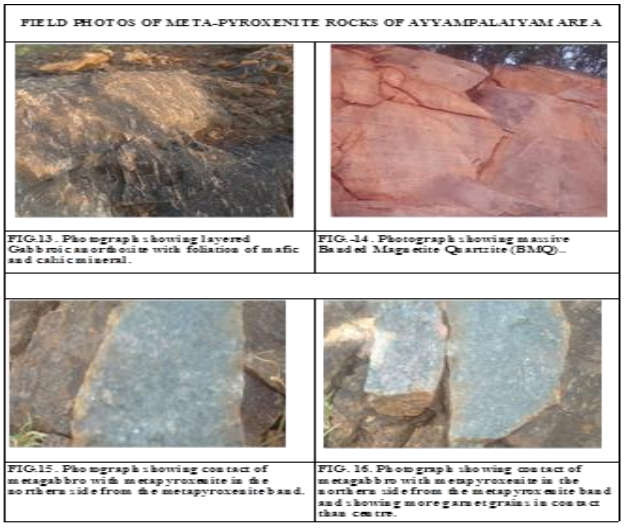
- ✓ Planning for field work
- ✓ Observations, mapping and collecting data by examining all geological features of the ground.
- ✓ Laboratory studies.
- ✓ Computing, Synthesis and subsequent interpretation of data through application of modern techniques.
- ✓ Finally the state of preparing geological map with report of the work.

A systematic representative samples of different rock types were collected. About 200 fresh and unaltered rock samples representing different rock types of the area from different locations were collected. The collected samples were numbered with location. Utmost care was given while taking measurement of attitudes and structural features and also in the collection of representative samples.

Theoretical Considerations:

The Platinum group o f elements (PGE) comprise of six elements and can be divided into two groups: the Ir-group PGE (IPGE = Osmium (Os), Iridium (Ir), Ruthenium-(Ru) and the Pd- group PGE (PPGE = Rhodium (Rh), Platinum (Pt), Palladium (Pd). The two groups are characterized by different solubility insilicate magmas, the IPGE being more refractory and compatible than the low-melting PPGE (Barnesetal,1988). Totally 222 Platinum Group of Mineral (PGM) is identified till date. PGE are siderophile in nature, though they can also be chalcophile in particular, geochemical environment. PGE concentrated in the earth's core and mantle during early history of the planet (Jagoutz et al, 1979; O'Neill, 1991) and consistently with this geochemical behaviour, their crustal "Clarke" values are remarkably low, frequently close to the detection limits. Transfer of PGE from the mantle into the crust is confined to specific geodynamic areas in which important mantle-crust interaction (Abduction of mantle fragments, Intersection of mantle- derived melts; Naldrett, 1981). PGE are geochemical monitors of these geological processes and able to give information about the petrological nature and evolution of the mantle source from which they were derived. The Platinum group of elements always accompanies one another due to their atomic volumes being similar. The PGE are chemically inert with high melting points (1552^0 to 27000^0 C). Owing to these properties, they get concentrated in the early cumulates of the magmatic crystallization like dunite, pyroxeniteetc preferably in chromite and magnetite.

Result: Figure 2: Field Photos



Description of Rock Types:

Banded Magnetite Quartzite (BMQ):

Banded magnetite quartzite occurs in all three areas. It is thin impersistent linear bands are present in Mallanayakkanpalaiyamarea. In Solavanurarea BMQ bands are traceable from east to west along with metaultramafics. In Ayyampalaiyamarea, the BMQ bands are exposed as conspicuous low ridges exposed over hill tops / slopes within the gabbroic anorthosite / anorthositicgabbo, hornblende biotite gneiss and charnockite. In the NW part MQ band occur 1.25 km SSW of Ayyampalaiyam within the anorthositic gabbro which are highly sheared and deformed as indicated by the sigma type porphyroblasts of garnet and is closely associated with talc tremolite schist. In the 400 hill, 1.80 km east of Ayyampalaiyam the BMQ band is exposed in the northern flanks of the hill and occurs within the anorthositic gabbro. Limonitic stains and sulphur encrustations are observed in the eastern end of the band and are highly sheared. Another band of BMQ is observed within the hornblende biotite gneiss 750 m SSW of Chinnkallipatti and is cut by a NNE trending dolerite dyke.

Charnockite:

Freshly cut surface show it to be massive but the weathered surface distinctly of exfoliation exhibits foliation. The charnockite is grey to greenish grey hard, compact and massive with greasy luster. It is composed of smoky pale grey or blue quartz, feldspar, hypersthene, biotite and opaque. Both garnetiferous and non garnetiferous varieties are present.

Hornblende Biotite Gneiss:

Hornblende biotite gneissbelonging to Bhavani Gneissic Complex / Migmatite Complex forms the most extensively developed rock type in the area. It does not constitute any positive relief and occupies the pediplains and hill slopes. The hornblende gneiss is seen in close association with the charnockite. The latter occurs as patches within it and vice versa. However, the contact between hornblende gneiss and charnockite is diffusive.

Anorthositic Gabbro / Gabbroic Anorthosite:

The anorthositic gabbro (mela gabbro) / gabbroic anorthosite (leuco gabbro) of the differentiated sequence form the major rock type in the Mettuppalaiyam Ultramafic Complex. This layered anorthositic gabbro / gabbroic anorthosite is exposed mainly in the Solavanur and Ayyampalaiyamareas. A massive body of the anorthosite is present in the south of metapyroxenite band in Solavanur and is shown in geological map. The anorthositic gabbro / gabbroic anorthosite in the western portion trends in NE – SW direction while that in southern portion trend ENE – WSW. Good exposures in the NW part are observed in the Modur – Pedikuttai R.F, south of Ayampalaiyam and north of Periyakallipatti. In the SW this lithounitoccurs which very in dimensions from lenses to major linear bands as well as detached lenses. Under thin section, the rock is medium grained and hypidiomorphic. Subophitic texture is noticed occasionally wherein retrograded pyroxene is enclosed by plates of plagioclase. Plagioclase is mostly calcic with platy or lath shaped, exhibits albite and carlsbad twins. Mafic minerals are mainly euhedral to subhedral hornblende and biotite. Magnetite, apatite and sphene occur as accessory minerals. Magnetite occurs as independent grains as well as released opaque along the cleavage planes. In the NE part, a continuous major band of anorthositic gabbro / gabbroic anorthosite is exposed from Solavanurupto Mallanayyakkanpalaiyam within the gneissic complex, which is sheared and migmatised. The entire differentiated sequence from dunite – anorthosite representing the MUC is well preserved in this sector. The various litho units occur in order of predominance include meta-gabbro / garnetiferous meta- gabbro, gabbroic anorthosite / anorthositic gabbro, amphibolite, meta-pyroxenite ± chromite, talc-tremolite schist, dunite and anorthosite. The rock is generally medium grained. It is essentially composed of felsic minerals such as plagioclase and mafic minerals such as hornblende. The anorthositic gabbro is mesocratic with mafics dominating over the felsic minerals and gabbroic anorthosite is leucocratic with felsic minerals dominating over the mafic minerals. Since both the types occur close to each other and since it is difficult to separate in a differentiated sequence. Cumulus texture is observed at places that is formed and concentrated primarily by fractional crystallization with interstitial pyroxene.

Garnetiferous Meta-Gabbro:

Garnetiferous meta-gabbro is exposed in all three areas. Garnetiferousgabbros outcrops are predominantly present in the Ayyampalaiyam area at southern side form talc tremoliteactinolite band. It is not cobanded nature in this area. Talc tremoliteactinolite schist is exposed in this area. It is co banded with metasedimentary banded magnetite quartzite and interbanded with anorthositic gabbro. Profuse coarse grained garnets are present in the contact zone of gabbro. Garnetiferous meta-gabbro forms the most dominant rock type of the Ultramafic Complex, which stands out prominently as linear strike ridges. In the NW part garnetiferous meta-gabbro is observed as a liner strike ridge extending from south of Chinakallipatti to 518 hill located 750 m south of Periyakallipatti. In the NE part this major band continues in the 392 peak near Indiranagar which is the eastern extension of 518 hill and further west in 316 hill upto Madappalaiyam.

Quartzofeldspathic Gneiss + Garnet:

Quartzofeldspathic gneiss of Migmatite Complex forms the dominant rock type in the northwestern part of the mapped area adjoining the Bhavani Sagar Reservoir. The rock is hard and compact, medium, grained,

leucocratic and is well foliated. It is mainly composed of abundance of quartz, feldspar and garnet with minor mafic minerals distinguishes from the hornblende biotite gneiss. Enclaves of the mafic – ultramafic variants comprising of gabbro / anorthositic gabbro, pyroxenite / metapyroxenite and amphibolite occur within these gneisses in the Modur – Peddikuttai R.F. The quartzofeldspathic gneisses are highly sheared and deformed with the development of mylonite, feldspar augens and winged garnet porphyroblasts. Under thin section the rock is essentially composed of quartz 45 – 20%, alkali feldspar 20 – 30%, plagioclase (albite –oligoclase) 30 – 40%, mafics (hornblende and biotite) 10%.

Petrography:

Hornblende Biotite Gneiss:

These are megascopically banded rocks with alternating felsic and mafic bands. The felsic and mafic constituent show an alternating planar arrangement in hand specimen. The foliation becomes more pronounced due to the parallel alignment of the prismatic grains of hornblende. The felsic streaks also exhibits a good linear disposition. The chief constituents are quartz, feldspar, hornblende and biotite.In thin sections, the constituent minerals in Reg. APM – 5/12, SL – 3/5 show considerable variation in grain size with well-defined planar orientation of biotite plates. The quartz grains are arranged with parallel elongation and as ellipsoidal aggregates and show presence of inclusions. Potash feldspar is orthoclase and show occasional alteration to sericite. Under crossed nicolsbiotite show moderate birefringence and higher order interference colour. It shows straight extinction on cleavage traces. Biotite flakes are more or less fresh, and are devoid of any kind of inclusions. Accessory mineral is magnetite and it is an opaque mineral. Based on thin section studies, the common mineral assemblage of this rock type is listed below.Quartz + Orthoclase + Biotite + Plagioclase + Hornblende + Magnetite

Microphotos:

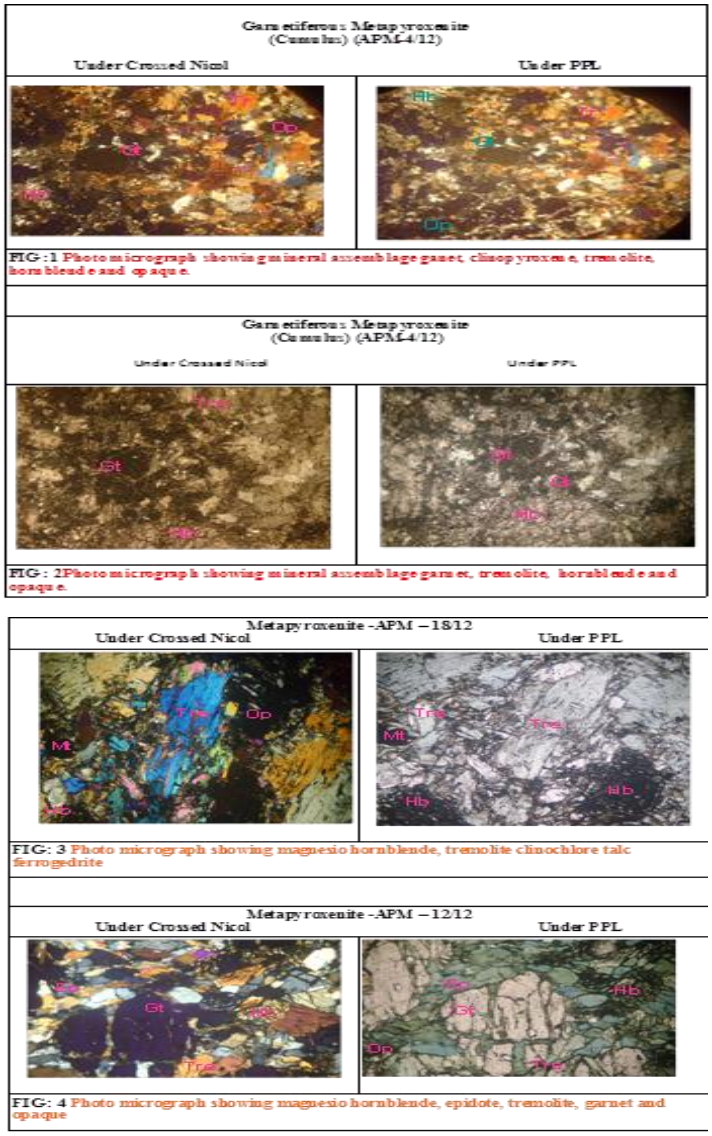


Figure 3: Microphotos

Metapyroxenite -APM- 17/12

Under Crossed Nicol | Under PPL

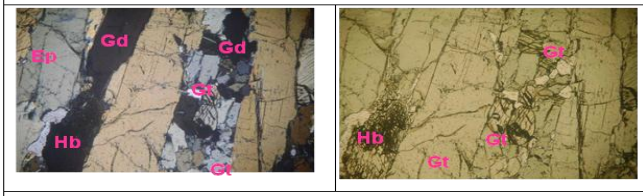


FIG : 5 Photo micrograph showing magnesio hornblende, tremolite, and titanite.

Metapyroxenite -APM – 2/12

Under Crossed Nicol | Under PPL

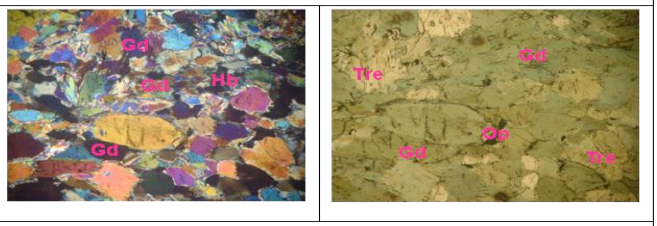


FIG : 6 Photo micrograph showing tremolite ,magnesio hornblende, ferro gedrite.

Major Elements Analysis of the Mafic - Ultramafic Rocks of Ayyampalaiyam Area (A –Area) In Mettupalaiyam Ultramafic Belt (MUB):

Table 1

Percentage of Oxides.	Meta-Gb	–Py	–Py	–Py	–Py	–Py	–Py	–Py
Sample No.	APM-2/12	APM-7/12	APM-10/12	APM-12/12	APM-13/12	APM-16/12	APM-17/12	APM-18/12
SiO_2	48.60	47.22	48.41	44.03	47.83	49.17	45.85	52.08
TiO_2	0.58	0.94	0.56	0.33	0.62	0.50	1.07	0.19
Al_2O_3	9.26	12.75	9.44	8.66	9.28	5.89	13.06	4.77
Fe_2O_3	13.00	15.37	13.39	29.58	16.41	16.42	17.11	11.19
MnO	0.23	0.24	0.24	0.28	0.23	0.19	0.28	0.23
MgO	**15.03**	**11.87**	**15.01**	7.27	**13.90**	**21.55**	**10.90**	**20.53**
CaO	12.16	9.78	11.88	8.56	10.69	5.38	9.99	9.99
Na_2O	0.85	1.50	0.80	0.60	0.83	0.69	1.43	0.88
K_2O	0.18	0.20	0.18	0.18	0.20	0.09	0.21	0.08
P_2O_5	0.10	0.13	0.08	0.50	0.19	0.12	0.10	0.05
SUM	**99.99**	**100.00**	**99.99**	**99.99**	**100.00**	**100.00**	**100.00**	**99.99**
Sc (ppm)	31	41	23	37	28	14	47	13
V (ppm)	198	213	184	150	209	108	230	96
Cr (ppm)	**2046**	757	**2056**	369	1460	**2084**	623	**3316**
Co (ppm)	76	72	64	30	76	121	73	61
Ni(ppm)	406	322	**438**	18	**416**	**925**	277	**671**
Cu (ppm)	76	8	39	22	71	33	11	8
Zn (ppm)	146	93	147	51	133	134	92	86
Ga (ppm)	11	12	12	8	11	10	12	8
Rb (ppm)	5	5	6	7	6	4	6	5
Sr (ppm)	24	102	26	27	22	20	87	67
Y (ppm)	14	38	13	37	14	10	45	13
Zr (ppm)	51	102	43	58	47	38	102	38
Nb (ppm)	4	18	4	5	7	5	24	3
Ba(ppm)	40	38	41	47	50	13	66	18
Pb (ppm)	6	3	4	4	4	3	5	2
Th (ppm)	2	2	2	2	2	2	2	2
U (ppm)	1	1	1	1	1	1	1	1

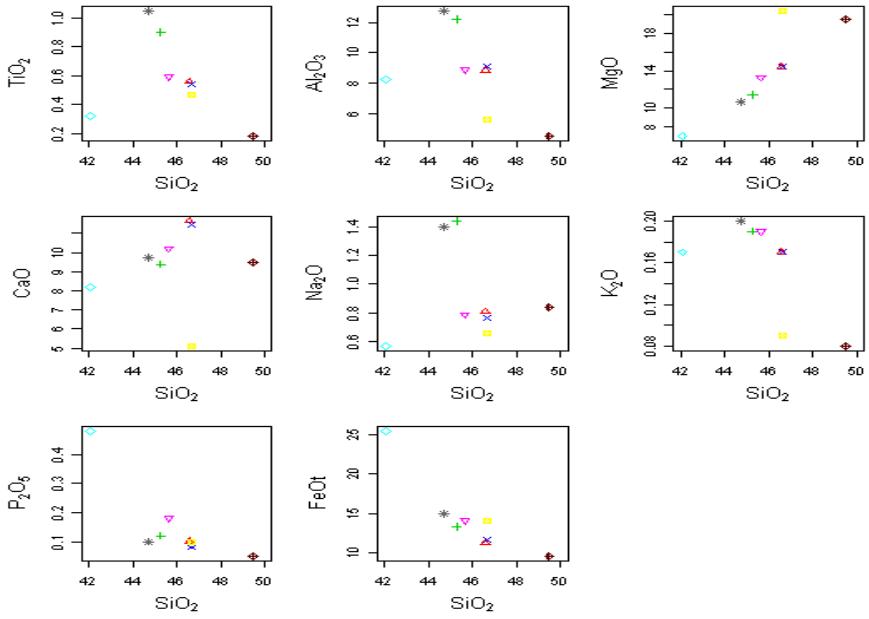
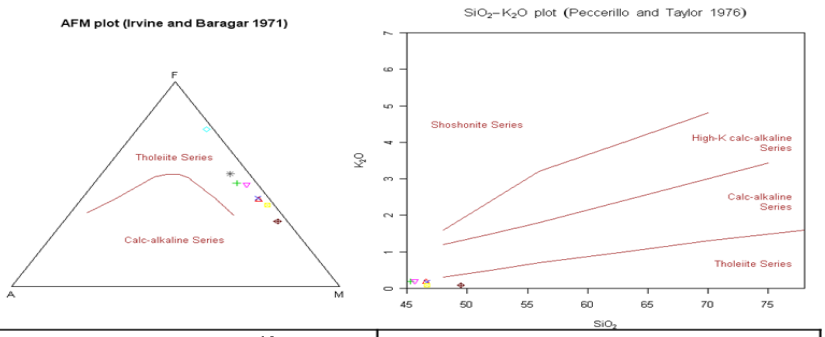
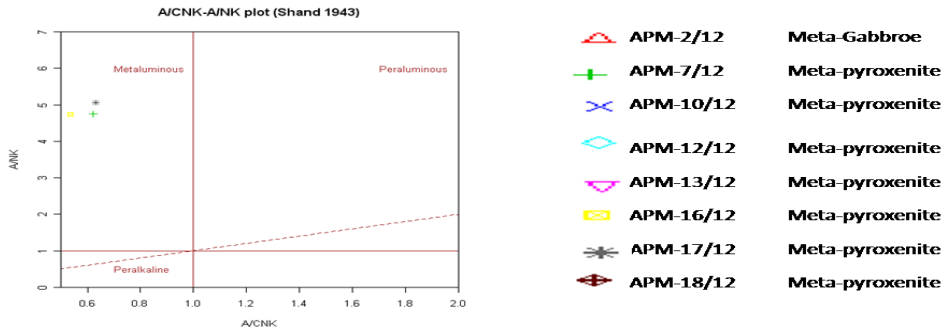


Figure 4



AFM =(A=Na_2 O+K_2O, F= $FeO^{(t)}$M=MgO) diagram showing the plots of metapyroxenite/metagabbro suite of rocks (After Irvine and Baragar 1971))

SiO_2 -K_2O diagram showing the plots of metapyroxenite/metagabbro suite of rocks (After Peccenllo and Taylor1976)



A/CNK-A/NK diagram showing the plots of metapyroxenite/metagabbro suite of rocks (After Shand 1943)

Figure 5: Binary Variation Diagrams

Binary variation diagrams are showing the plots of metapyroxenite/metagabbro suite of rocks a) SiO_2Vs $TiO_{2,}$ b) SiO_2Vs $A_2lO_{3,}$ c) SiO_2VsMgO, d) SiO_2VsCaO, e) SiO_2Vs Na_2O, f) SiO_2Vs K_2 O, g) SiO_2Vs P_2 O_5 & f) SiO_2VsFeO$^{(t)}$

Conclusion:

In Ayyampalaiyam area is consist of more exposure of metasedimentaries, meta basics and metaultramaficlithounits are present. In this area two metapyroxeniteb and has been traced such as northern and southern band. Northern band of metapyroxenite is cobanded with metagabbro with sharp contact in the eastern side and the western side is hilly area with talcos of metapyroxenite. But this band is also co-banded with metagabbroicanorthosite. The southern meta-pyroxenite band is gradatinally contact with metagabbro. Predominatly presence of Cr in ppm level in more samples with passitivecorelation of Ni.

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