Geology and Geochemistry of Banded Iron formation (BIFs) in Kavuthimalai-Vediyappanmalai Region, Thiruvannamalai District, Tamilnadu, India

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Abstract

The present study describes the field, Petrology, Geochemistry and origin of banded iron formation In Kavuthimalai-Vediyappanmalai region, Thiruvannamalai district, Tamilnadu, India. The field relationship with Pyroxene granulites, Charnockites, Granite gneisses, The BIF in these formations is mainly banded magnetite quartzite associated with amphibolites, granulites, etapelites, sillimanite-quartz schists and pyroxenites. The samples of study area BIF show the average as Mn (194 ppm), Ni (21 ppm), Ti (240 ppm), Co (7 ppm), Cr (109 ppm) and V (35 ppm). The average values of ferride group elements of iron formations of Kanjamalai, Godumalai, Tirthamalai and Kavuthimalai and Vediyappanmalai regions in which, few samples have very poor concentrations compared to the samples of other regions. The presence of low concentration of ferried group elements of the study area BIF indicates that the iron formation of the study area is metasedimentary origin.

Key words: Geochemistry, Iron formation, kavuthimalai-Vediyappanmalai,

Thiruvannamalai.

INTRODUCTION

The Banded Iron formations of Tamilnadu are a group of pre-cambrian iron formations occurring as narrow, highly deformed and metamorphosed rocks within the Archaean granulites and gneisses. The iron formations of Granulitic terrain in Tamilnadu, Karnataka and kerala states of India have been named "Tamilnadu Type" (Radhakrishna et, al., 1986). The information on the conditions of deposition, Nature of the depositional basin, Stratigraphy, Structure, Tectonic, Geochemistry, Mineralogy, daigenetic changes and metamorphism are scanty (Subba Reddy and Prasad, 1982). The present study is an attempt to describe detail about the field, Petrography, Geochemistry of banded iron ore formatons of Kavuthimalai-Vediyappanmalai regions of Thiruvannamalai district, Tamilnadu.

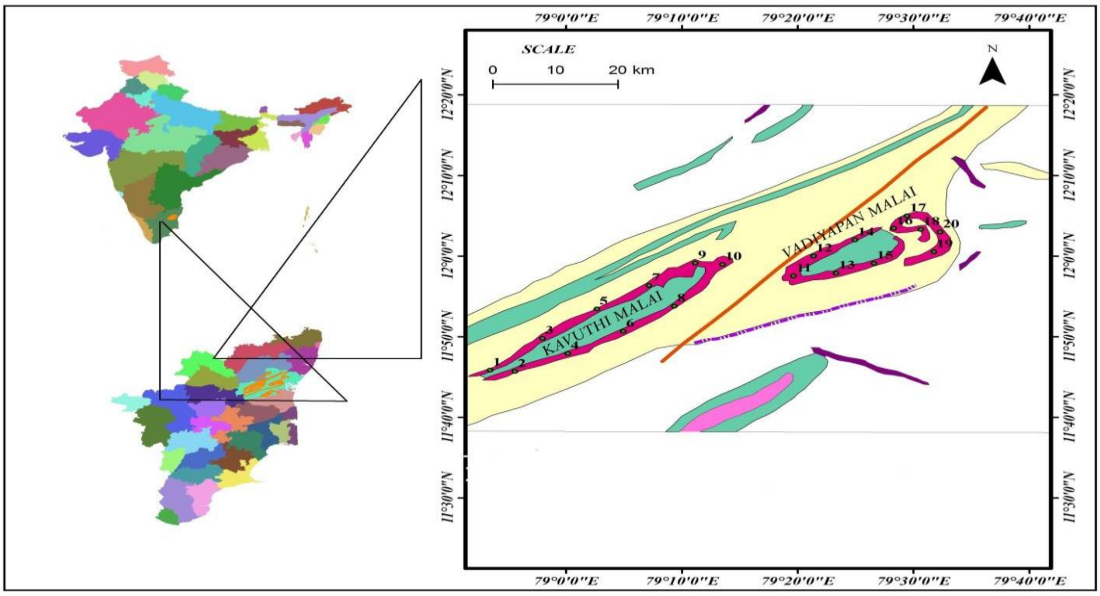


Figure.1. Location of the Study area map

GEOLOGY OF STUDY AREA

The study area forms the part of Granulitic terrain of south India. It lies between 120 15' – 120 19' North latitudes and 780 58'- 790 05' East longitudes around Kavuthimalai- Vediyappanmalai regions, Thiruvannamalai District, Tamilnadu. In this area pyroxene granulites and Banded Iron Formations (BIFs) are according to their order of superposition. The pyroxene Granulites, Charnockite and Granite Gneisses show sharp contacts with one another. The Charnockites have xenoliths of pyroxene granulites, which indicate the former as younger. The BIFs deposited after the fault zone was taken place in NE-SW direction and later metamorphosed.

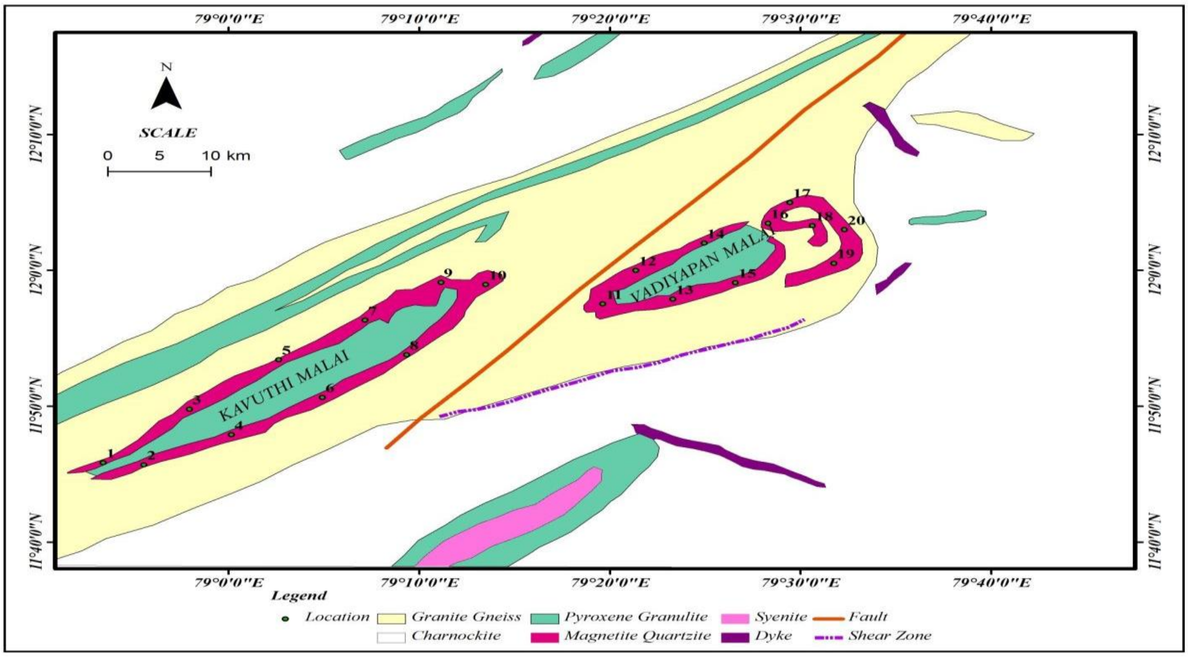


Figure. 2. Geology of the Study area

The BIFs in the western portion of the Fault occur as steeply dipping on the top as basin- like structure. The rock show distinct banding, due to the occurrence of thin discontinuous ribbons and laminae of quartz alternating with those rich in dark iron minerals. The BIFs are well banded rocks consisting of millimeter to centimeter thick alternating iron - rich and silica – rich layers. The ore in the northern limb is medium to coarse grained, while in the southern limb it is usually medium grained.

PETROGRAPHY

The petrogrphically the BIFs composed of Magnetite and quartz with minor proportions of hypersthene, hedenbergite; commingtonite/grunerite, garnet and apatite are noticed in these rock formations. Magnetite occurs as irregular grains or bands. The association of magnetite with quartz ranges from granular to well banded nature with alternate layers of quartz and magnetite. Numerous cracks in quartz filled with iron oxide are present. In some cases the veins appear to be feeding the iron oxide bands. In some sections fine hair like cracks from the iron oxide grains extends in to quartz grins, which form a mesh like network.

The under reflected light magnetite is grey in color with brownish tinge. The octahedral and cubic parting planes are noticed. The cubic nature of parting planes indicated by triangular pits. In some samples magnetite shows faint anisotropism due to the presence of martite formed by martitistion, along the octahedral parting planes and thus giving rise to a network of triangular lattice pattern. Martite is identified by its high reflectance than magnetite and by its light grey in color with bluish tinge.

Quartz is the dominant mineral in many assemblages. It occurs as elongated grains and alternate bands with magnetite. This mineral is also occurs as inclusions in magnetite. The grain size is observed to be finer at the contact with magnetite than far off. The deformation effects in quartz are marked by marginal granulation and development of numerous cracks filled with iron oxide. The individual grains of quartz contain dust like numerous inclusions of magnetite.

GEOCHEMISTRY

The geochemical studies, major oxide, trace elements were carried out using XRF and ICP-MS. These geochemical data were used for understanding geochemical characteristics of BIF of the study area. Samples were collected generally were fresh part of the outcrop area. Samples were crused, grained and powdered for preparation of chemical solution using standard procedures.

MAJOR ELEMENTS

The major oxide results of analyses of SiO_2 ranges from 39.20 to 47.55%, TiO_2 0.10 to0.48 %, Al_2O_3 0.10 to 0.63%, Fe_2O_3 37.75 to 44.75%, FeO 6.90 to14.28%, MgO 0.52 to 2.00%, CaO 0.23 to1.25%, Na_2O 0.10 to 0.65%, K_2O 0.10 to0.40%, MnO 0.10 to 0.30%, P_2O_5 from 0.15 to 0.43%.

Table.1. Chemical composition (wt %) of Magnetite- quartzite of Thiruvannamalai.

Major Elements (WT %)											
Elements	1K	2K	3K	4K	5K	6V	7V	8V	9V	10V	Average
SiO2	47.55	48.10	47.20	46.00	46.10	43.65	39.20	47.10	42.51	44.89	44.62
TiO2	0.32	0.23	0.48	0.20	0.20	0.25	0.35	0.10	0.33	0.40	0.22
Al2O3	0.10	0.35	0.30	0.33	0.15	0.63	0.56	0.32	0.35	0.36	0.35
Fe2O3	49.07	54077	50.48	50.75	51.45	49.72	56.90	57.28	56.44	53.14	53.00
MgO	1.00	1.45	1.05	0.50	1.45	1.15	2.00	0.52	0.75	0.25	1.21
CaO	0.85	1.25	0.50	1.22	1.24	0.30	0.23	0.35	0.43	0.63	0.70
Na2O	0.15	0.18	0.19	0.17	0.10	0.22	0.65	0.15	0.22	0.30	0.23
K2O	0.10	0.17	0.15	0.10	0.10	0.20	0.15	0.40	0.13	--	0.17
MnO	0.20	0.24	0.30	0.21	0.28	0.23	0.22	0.22	0.10	0.25	0.23
P2O5	0.28	0.15	0.27	0.35	0.29	0.39	0.43	0.15	0.28	0.20	0.28

Trace Elements (ppm)

Elements	1K	2K	3K	4K	5K	6V	7V	8V	9V	10V	Average
Co	6.00	8.00	10.00	--	5.00	---	---	--	--	--	7.00
Cr	85.00	81.00	102.00	75.00	98.00	156.00	120.00	143.00	94.00	135.00	109.00
Ni	15.00	19.00	17.00	16.00	12.00	22.00	26.00	28.00	23.00	25.00	21.00
V	38.00	23.00	26.00	20.00	39.00	42.00	56.00	43.00	32.00	31.00	35.00
Cu	16.00	14.00	32.00	25.00	26.00	28.00	19.00	19.00	30.00	23.00	23.00
Ba	28.00	16.00	18.00	21.00	40.00	22.00	13.00	30.00	19.00	26.00	23.00
Sr	16.00	13.00	6.00	8.00	12.00	24.00	10.00	19.00	26.00	18.00	15.00
Co/Ni	0.40	0.42	0.59	--	0.41	--	--	--	--	--	0.46

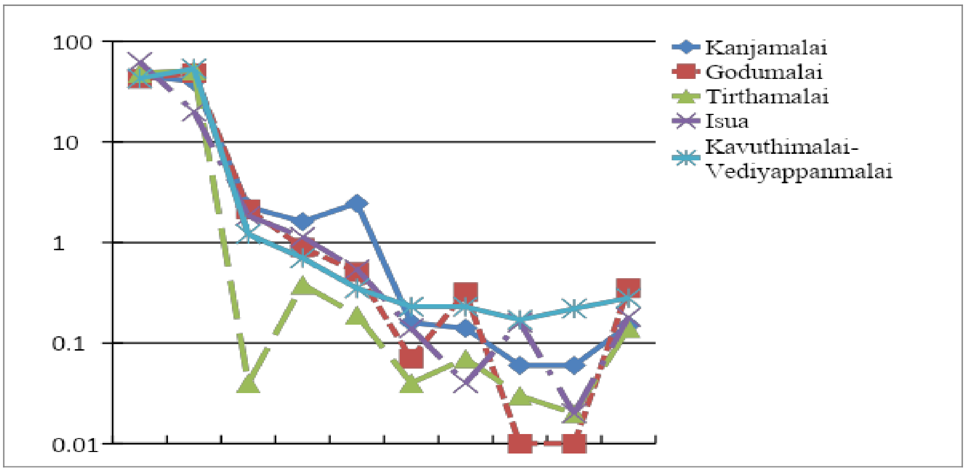
Table 2. Comparison of the study area major element (wt %) with other BIF type's areas of the world

Elements	1	2	3	4	5
SiO_2	45.06	42.28	48.00	61.99	42.62
Fe_2O_3	39.64	47.94	51.00	19.95	53.21
MgO	2.24	2.13	0.04	1.84	1.21
CaO	1.61	0.89	0.38	1.13	0.70
Al_2O_3	2.45	0.51	0.19	0.54	0.35
MnO	0.16	0.07	0.04	0.14	0.23
Na_2O	0.14	0.32	0.07	0.04	0.23
K_2O	0.06	0.01	0.03	0.16	0.17
TiO_2	0.06	0.01	0.02	0.02	0.22
P_2O_5	0.15	0.35	0.14	0.18	0.28

1. Average of Kanjamalai BIF (Rajendran et al. 1996), **2.** Average of Godumalai BIF (Rajendran et al. 2007), **3**. Average of Tirthamalai BIF (Thirunavukkarasu et al, 2009) **4.** Average of Isua BIF (Dymek and Klein 1988). **5**. Average of the Study area BIF.

When the average values of the Kanjamalai, Godumalai, Tirthamalai, Isua and Study area are plotted against the respective oxide percentages is observed that significant variation in Fe_2O_3 and low SiO_2 proportions which are high in the study area BIFs, where as Al_2O_3 and MgO, CaO are in much lower proportion in Kanjamalai BIF. The average proportions of MnO, K_2O, and TiO2 of study area BIF show high and similar to the Isua BIFs. MnO of the study area is similar to Kanjamalai BIF. Low Na_2O, P_2O_5 of the study area is similar to Kanjamlai, Tirthamalai, Isua BIF but it is higher in the Godumalai BIF.

Figure 3. Average of major elements of study area BIF is compared with Other BIF of the world.



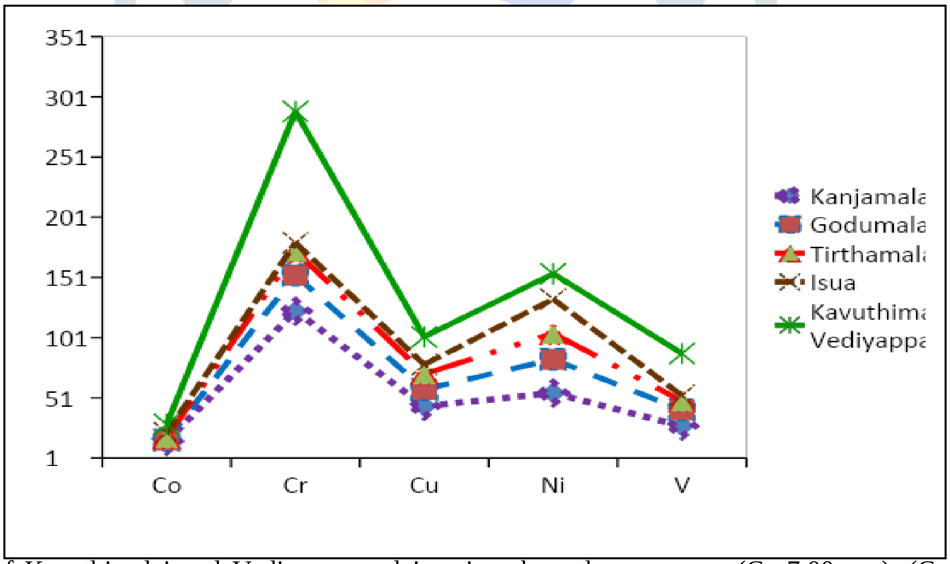
The average major element composition of the study area is compared with the other iron formations of Kanjamalai, Godumalai (India)., Isua iron formations (Table 3 and Figure. 4; Rajendran, 1996; Rajendran et al., 2007; Dymek and Klein, 1988; Gross and Macleod, 1980). The comparison of major elemental data infers that the iron formations of the study area are rich in concentration while comparing to the formations of Isua region.

TRACE ELEMENTS IN (BIF)

Table 4. Trace Elements of study area compared with other BIF of the world.

Elements in ppm	Kanjamalai	Godumalai	Tirthamalai	Isua	Study Area
Co	15.00	0.76	2.20	4.10	7.00
Cr	123.00	29.80	20.00	7.00	109.00
Cu	44.00	14.00	13.00	7.60	23.00
Ni	55.00	28.00	21.50	28.50	21.00
V	27.50	13.50	7.40	4.50	35.00

Figure 4. Trace Elements of study area compared with other BIF of the world.



The samples of Kavuthimalai and Vediyappanmalai region show the ranges as (Co-7.00ppm), (Cr-109.00ppm), (Ni-21.00ppm), (V-35.00ppm), (Cu-23.00ppm).

COBALT

The Cobalt in BIF of Orissa is <10ppm (Majuder et al.1982). 10ppm in iron ore group (Majunder1982). In C N Halli. It is <50ppm (Devaraju, 1986) and in Sargur BIF it is 25 ppm (janarthan et al 1986), in the present area it ranges from 5-10 ppm Goldsmith (1958) revealed that the amounts of Ni an iron sediment are very less and same opinion was expressed by Landergren (1948). Generally, in sedimentary iron ores Co content is, 10 ppm. In the study area also the Co is in the same range.

NICKEL

The Nickel content in the BIF of the present area ranges from 20-56 ppm within an average of 21. In Sedimentary iron ores of Bihar and Orissa it is between 10.25 ppm (Chakrabothy and Mujunder 1986), in CN Halli iron ore formations the content is <20 ppm (Devaraju et al, 1986), in Sargur BIF, it is 22 ppm (janarthan et al, 1986), the Co/Ni ratio for Sedimentary iron oxides is less than unity according to Frintsch (1978).The ratio for the present area is in the order of 0.40 to 0.59 within average of 0.455, which also supports the sedimentary origin.

CHROMIUM

The chromium contant in Sargur BIF is 58 ppm (janarthan, 1986), in the iron ore group it is 15 ppm (Majunder, 1982), in BIF of Orissa it is 10-25 ppm, in CN halli it is 70 ppm (Devaraju, 1986), The Clarke valve for the sediments is 110 ppm and for igneous rocks it is 200 to 2000 ppm. The study area has an average of 109 which is found to be below the Clarke value and thus indicating the origin of such ore as oxides (Landergren, 1948).

VANADIUM

Vanadium ranges from 20-56 ppm with an average of 35 in the study area Goldsmith (1958) expressed the view that the Vanadium content in sediments generally very low when compared to the upper lithosphere. For sedimentary iron ores of Central Sweden and Ongole the vanadium content is 10-16 ppm (Sastry and Krishna Rao, 1970), for BIF of C N hill. It is 50 ppm (Devaraju, 1986), for Sargur BIF (Janarthan, 1986), it is 11 ppm and for iron formations of Bihar and Orissa it is 20 to 50 ppm (Chakraborthy and Majunder, 1986),

COPPER

The copper content of the present area has an average of 23 ppm with a range of 14 to 30 ppm is analogous to the sedimentary iron ores of Bihar and Orissa. 10-20 ppm (Chakraborthy and Majunder, 1986) and iron ores of central Sweden and Ongole of 10 to 50 ppm (Sastry and Krishna Rao, 1970).

FERRIDE GROUP ELEMENTS

The analyses of Ferride group elements of BIF of the study area interpreted with other iron formations. The concentration of ferride group elements namely Mn, Ni, Ti, Co, Cr and V of the iron formations of the study area are given in Table 3. The samples of study area BIF show the average as Mn (194 ppm), Ni (21 ppm), Ti (240 ppm), Co (7 ppm), Cr (109 ppm) and V (35 ppm. The average values of Ferride group elements of iron formations of Kanjamalai, Godumalai, Tirthamalai and Kavuthimalai and Vediyappanmalai regions in which, few samples have very poor concentrations compared to the samples of other regions.

Table 5. Comparison of the average values (in ppm) of Ferride elements of Kavuthimalai-vediyappanmalai iron formations with the iron formations of Tamilnadu, India.

Name of Regions	Mn	Ni	Ti	Co	Cr	V
Kavuthimalai-Vediyappanmalai	194.60	21.00	240.80	7.00	109.00	35.00
Kanjamalai	86.56	53.75	155.81	13.62	115.43	22.43
Godumalai	310.00	20.00	311.00	3.14	38.00	9.80
Tirthamalai	356.00	21.00	146.00	2.20	20.00	7.40

The samples of Godumalai region shows the concentration of elements in the range of Mn (310.00 ppm); Ni (20.00 ppm); Ti (311.00 ppm); Co (3.14 ppm); Cr (38.00 ppm); and V (9.80 ppm). The results show that all samples exhibit low concentrations compare to other iron formations. Kanjamalai region show the concentration of such elements in the range of Mn (86.00 ppm); Ni (53.75 ppm); Ti (155.81 ppm); Co (13.62 ppm); Cr (115.43 ppm); and V (22.43 ppm).

The results of interpretation of samples of all regions show not much variation among the formations in the concentration of ferride group of elements and exhibits similar trends. The low concentrations of these elements indicate the source of materials derived from weathering of land masses and not from any volcanic sources. These iron formations are later metamorphosed. Among the elements, the Mn, Ti and Cr are enriched compared to other elements are indicating that the iron formations of the study area are of meta-sedimentary origin (Saravanan, 1969; Krishna Rao and Kasipathi, 1991 and Rajendran 2000, 2008).

Lander Gren (1948) suggested that the low concentration of these elements in many iron formations of central Sweden indicating the sedimentary origin. Also the average concenterations of ferride group elements of study area BIF are compared with iron formations of Tirthamalai, Godumalai, Kanjamalai region. (Anjaneya Sastry, et al 1970; Ramo Rao, 1971; Krishna Rao and Kasipathi, 1991, Thirunavukkarasu et al 2008). The samples of the study region show similar trend with other iron formations and indicating meta-sedimentary origin.

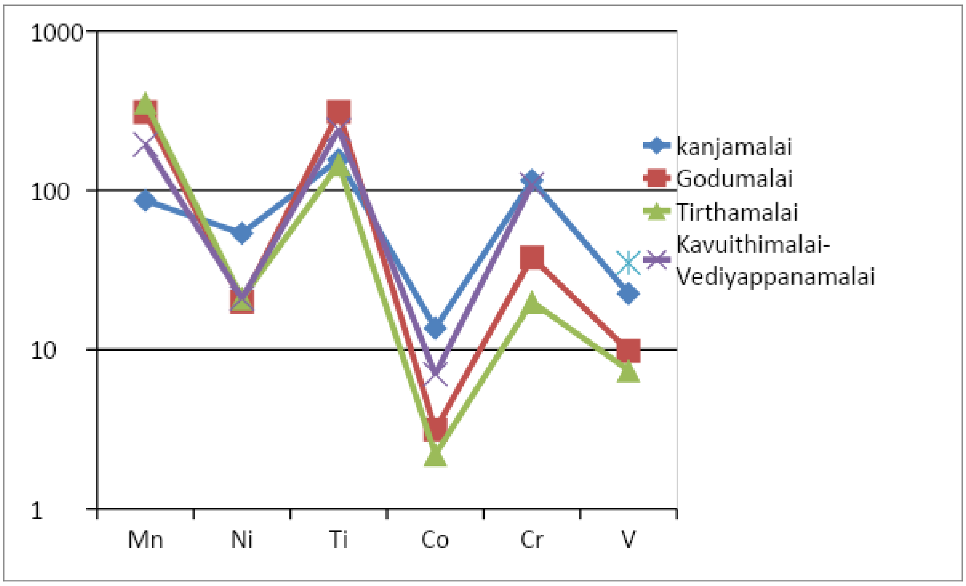


Figure 5. Comparision of Ferride group of elements of study area BIF with other iron formations.

CONCLUSION

The study area mainly consists of pyroxene granulites, Charnockites, granite gneisses and Banded Iron formation (BIF) according to their order of superposition. The geochemical analyses and interpretations of samples of the study area show the presence of high Fe2O3 and SiO2 contents (53-42%) and reveal the occurrence of high amount of magnetite and quartz minerals. All other major oxides like TiO_2, CaO, MgO, MnO, Na_2O, and K_2O are less than 0.4 wt % in the samples. The average major element compositions are compared with other iron formations namely Kanjamalai, Godumalai, Tirthamalai, Quartz Magnetite samples of Isua. It is observed that the iron formation of study area is having similar trend like other iron formations of the world. As well as, the average concentrations of Sc, V, Cr, Co, Ni, Cu and Zn are compared with the normalized average crustal abundance. It shows that these transition elements of study area iron formations are nearer to the average of crust and show an increase in relative depletion with decreasing atomic number. Also, the presence of low concentration of ferride group elements of the study area BIF indicates that the iron formation of the study area is metasedimentary origin. Thus, the geochemical study of Kavuthimalai and vediyappanmalai region shows that the iron formations have meta-sedimentary characters.

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