HYPERSPECTRAL SIGNATURE STUDIES ON PRICAMBRIAN ROCK TYPES OF SOUTHERN PART OF CHITRADURGA SCHIST BELT, DHARWAR CRATON, KARNATAKA, INDIA

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Abstract

Precambrian rocks of southern part of Chitradurga schist belt host economic minerals like Limestone, Dolomite, Iron, Manganese and Gold mineralization, hence the author is tried to build few spectral library of the altered and unaltered rocks of the study area by understanding the spectral properties of the minerals.Hyper-Spectral signatures are the representation of the spectral response of certain features in a graphical manner as a function of wavelength and reflectance measured by the ASD instrument. The Visible near Infrared – Short wave Infrared (VNIR-SWIR) regions of electromagnetic domain is characterized by the absorption resulted either due to the electronic process or vibrational process and these features delineates the mineral occurrences, the spectral character of the most of the minerals occur within a complex describes the spectral behavior of the rock.The intimate mixture (i.e. rock) of major minerals is identified mainly by above said two process, one the electronic process at less than 1.0 µm to delineate Fe^{2+} and Fe^{3+} and another process between the wavelength 1.0 to 2.5µm SWIR region of EMS shows diagnostic mineral features of AL-OH, Mg-OH, Fe-OH, Si-OH, CO_3 NH_4 and SO_4. The spectral analysis resulted in the determining the physico chemical properties of the mineral. The chemical analysis (XRF) and petrographic study of the Precambrian rocks given the parallel supports for the results of spectroradiometry.

Keywords: Hyperspectral signatures, Geochemistry, Petrography, Precambrian rocks, Chitradurga schist belt.

1. INTRODUCTION

Spectroscopy is the study of light interaction as a function of wavelength, interactions contain light emitting, reflection or scattering from any of the material. This principles are applied to get spectroscopy of the mineral and rocks with the help of spectroradiometry, spectroradiometry is used to measure the radiometric quantities like radiance and irradiance in a continuous bands of spectral ranges 0.4 to 2.5µ in the EMS. Imaging spectroscopy may also called as imaging spectrometry, or hyperspectral by remote sensing community, Imaging includes study of rock in the laboratory, a field study site from an aircraft or a planet observation through spacecraft/ Earth based Telescope. Hence, the name hyperspectral sensitivity has taken for this chapter heading, hyperspectral sensitiveness of different rocks and minerals from the Precambrian terrains of southern part of Chitradurga belt has dealt and details are given with reference to many earlier researchers (Clark 1993; Kruse 1997 Mustard and Sunshine, 1989; Green *et a*l., 1990; Clark et al., 1993; Goetz *et al*., 1985).The Imaging spectroscopy in this context is of purely the spectroscopic studies of rock in the laboratory environment. Precambrian rocks of southern part of Chitradurga schist belt host economic minerals like Limestone, Dolomite, Iron, Manganese and Gold mineralization, hence the author is tried to build few spectral library of the altered and unaltered rocks of the study area by understanding the spectral properties of the minerals. The Visible near Infrared – Short wave Infrared (VNIR-SWIR) regions of electromagnetic domain is characterized by the absorption resulted either due to the electronic process or vibrational process and these features delineates the mineral occurrences, the spectral character of the most of the minerals occur within a complex describes the spectral behavior of the rock(Hunt et al., 1977).The intimate mixture (i.e. rock) of major minerals is identified mainly by above said two process, one the electronic process at less than 1.0 µm to delineate Fe^{2+} and Fe^{3+} and another process between the wavelength 1.0 to 2.5µm SWIR region of EMS shows diagnostic mineral features of AL-OH, Mg-OH, Fe-OH, Si-OH, CO_3 NH_4 and SO_4 (Clark et al., 2007). The spectral analysis resulted in the determining of physico chemical properties of the mineral helps in the classification of pure pixels of the sensor based images.

2. METHODOLOGY

Spectroradiometer ASD FieldSpec3 is extensively used to measure the radiometric quantities (reflection and absorption of radiance spectra) by extracting different diagnostic spectral signature of the rock and minerals, the spectral signature studies and interpretation techniques are utilized to differentiate the minerals and mineral assemblage in the mixture (Kruse and Lefkoff., 1999).The representative 6 samples listed in the table 1.1 are the fresh samples used make the spectral studies. The rocks sample are sliced into 4”×5” to 5”×7” rectangular pieces. These sample size range is used by size norms of the sample analyzed at the Jet Propulsion Laboratory (JPL) National Aeronautics and Space Administration, USA (Baldridge 2009). Ten spot observation per sample are recorded to the selected samples from the study area, maximum of 3 to 4 best matched curves of a sample is given in the spectral signature profiles. The samples cut part given the best spectral curve respect to exposure surface of the sample (Rajendran et al., 2014; Ali M. Qaid and Basavarajappa. 2009; Basavarajappa et al., 2017 and 2018). Chemical analysis like X-ray florescence (XRF) is carried out for the study of elemental distribution in the whole rock composition. The petrography work done by the help of standard research level microscope is helped to mark out the individual minerals in the rock.

3. GEOLOGY OF STUDY AREA

The Chitradurga schist belt has been folded into light synforms and antiforms along NNW-SSE. Sirankatte gneiss occupies the core of one such antiform. The Dodguni anticline plunges NNW. The Kibbanahalli arm represents a synform. The gneissic area intervening between the Kibbanahalli and the Chitradurga belt is regarded as an antiform plunging in SE direction. Recent geophysical survey (seismic sounding) data indicated the existence of major thrust fault at the eastern margin of the Chitradurga belt. Some unpublished data from GSI revealed the metamorphism of rocks of CSB is that the Sargur group is undergone middle to upper amphibolite facies metamorphism, whereas the Dharwarsupergroup is metamorphosed in the lower amphibolite to greenschist facies of metamorphism.

Workable deposits of limestone, magnetite, gold and manganese occur in the study areaand manganese usually does not occur in nature in metallic form, but only in combination, usually in the form oxides, hydroxides, carbonates and silicates, a few mini cement plants have come into existence around Vobalapura and Sirankatte area, based on the cement grade limestone occurring within the Chitradurga Group. The cement grade limestone of Dodguni area is being worked by Mysore Cements Ltd, to feed their cement plant at ammasandra. Asbestos, barytes, corundum, vermiculite and soapstone occur sporadically in the area. Gold mineralization occurs along a shear zone within line of hydrothermally altered meta-volcanics in the submarine hydrothermal system (Bellara and Ajjanahalli) (Seshadri. et al 1986) and recently Nabarun pal et al., 2003 revealed the gold mineralization at Ajjanahalli as structurally controlled BIF horizon.

The southern part of the study mainly covered by the C.N Halli (Chikkanayakanahalli) schist belt (green stone belt) of the Dharwar super group of Karnataka (Bruce foot 1888, Rama Rao 1962). Lithostratigraphic sequence of this schist belt shows basement Archean granitoids overlain unconformably by sequence of middle Precambrian geosynclinals sediments and mafic rocks. Both the older granitoids and younger geosynclinals deposit have been cofolded into series of synform and antiforms, regionally metamorphosed under conditions corresponding to green schist-epidote-amphibolite facies and later intruded by suits of dolerites. The belt host huge deposits of iron formation by the Lake Superior type of deposits. Goldich 1973 noted the age of this formation in to middle Precambrian age covers the time span 2.3 to 1.9 b.y. Gneiss are the oldest rock types diconformably overlaid by quartzite, chlorite schists, carbonates, iron formations and amphibolite.

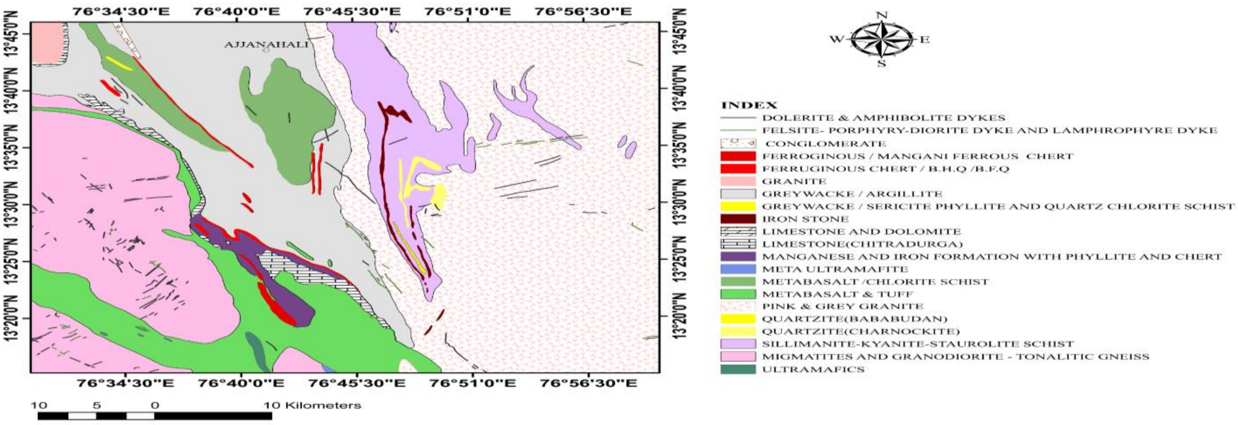

Fig.1 Geological map of the study area (Modified after GSI 1997)

Table 1.Details of location of the samples selected for spectral analysis

Sr. No	Sample No	Latitude & Longitude (DMSDS)	Location	Name
1	JT-5	N 13^0 20' 13.4" E 76^0 46'23.7"	West of Yellapura	Carbonate
2	JT-7	N 13^0 19' 39.4" E 76^0 42' 21"	Harenahalli	BIF (hematite)
3	JT-13	N 13^0 22' 51.1" E 76^0 40' 32.8"	Near Manchekatte	Green schist rock
4	MJ-10	N 13^{0}32' 13.25'' E 76^0 45' 51.19"	Haralakatte	Amphibolite
5	MJ -9B	N 13^0 33'54.35'' E 76^0 48' 14.51"	Near Kalinganahalli	Mica schist
6	JT- 22	N 13^0 28' 42.5'' E 76^0 51' 11.7"	GuddadaRangaswami temple	Biotite gneiss

4. PETROGRAPHY AND GEOCHEMISTRY

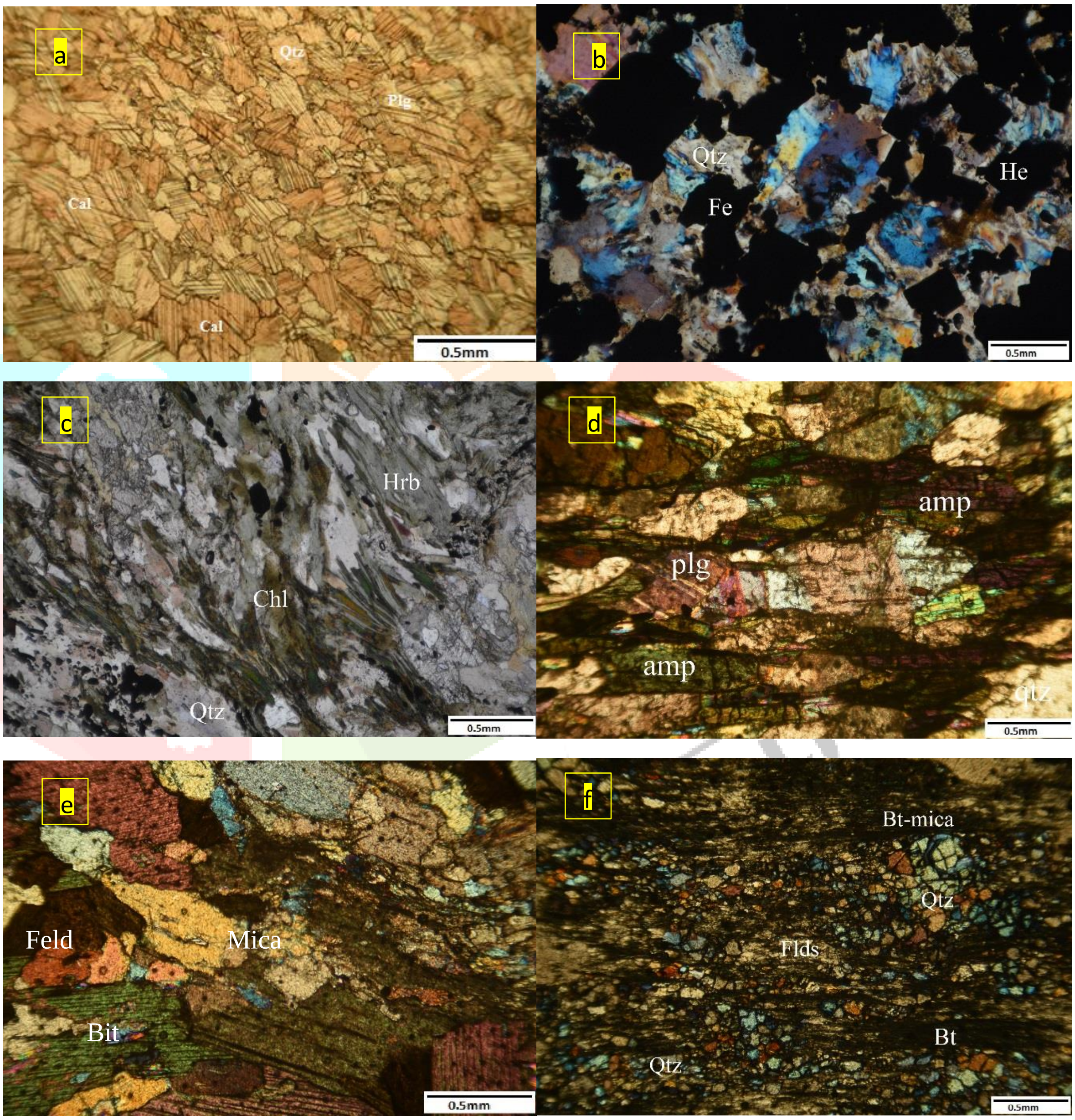

Fig.2 Microphotographs of a) Limestone b) Hematite quartzite c) Chlorite Schist d) Amphibolite e) Mica Schist f) Biotite Gneiss

Carbonate rock like limestone is showing abundance of calcite mineral occurrences in the thin sections, the two set of cleavage of calcite mineral is easily noticeable in the figure 2a and it is associated with minor amount of quartz and feldspar. The chemical analysis results shown the CaO percentage near to 47.62 with less silica content 6.38 %. The Banded iron formation in the study area is greatly contains the Fe mineral Hematite and intersperse with quartz layer. The euhedral opaque crystals of hematite mineral is clearly distinguishable with the quartz mineral association (figure 2b), the chemical analysis given the results with 47.32 percentage of Fe_2O_3 and 45.07 % silica content. Chlorite schist in the microphotograph depicts the well fledged foliation of chlorite and quartz mica minerals in the figure 2c. Amphibolite is showing some schistosity by aligning of amphibole and mica minerals with the quartz and feldspar (figure 2d). The chemical analysis of this rock shown the content of Fe, Mg and Ca oxide percentage 9.58, 9.00 and 10.61 respectively with higher silica percentage 48.70. The muscovite schist contains aggregates of Biotite, hornblende, quartz and feldspar, the muscovite mica alteration is clearly observable in the right part of the thin section (figure 2e). The XRF results are showing the more percentage of $AL_2O_3$with 29.87 and silica is of 51.98 percentage in whole rock chemistry. Biotite gneisses microphotograph exhibiting the gneissosity texture with alternating layer of biotite mica and quartz and feldspar (figure 2f), shearing of this rock leads to alignment mica and other mineral in unidirectional. The chemical analysis results shows the silica with 71.77% and Al2O3 with 14.99% and Na2O with 4.66% in the sample biotite gneiss.

Table 2 Details of selected rocks chemical analysis (XRF studies)

Laboratory Identification (%)	Limestone	BIF	Chlorite Schist	Amphibolite	Muscovite Schist	Biotite Gneiss
SiO2	6.38	45.07	49.76	48.70	51.98	71.77
Al2O3	0.21	1.08	12.80	15.59	29.87	14.99
Fe2O3	0.67	47.32 (FeO= 3.91)	9.86	9.58(FeO)	2.71	0.94
MgO	1.94	0.26	5.74	9.00	1.81	0.57
CaO	47.62	0.03	0.33	10.61	0.19	1.53
Na2O	0.05	0.21	0.33	2.10	0.20	4.66
K2O	0.05	0.01	1.04	0.19	6.75	3.99
TiO2	0.01	0.02	1.28	0.88	0.84	0.17
MnO	0.78	0.84	0.15	0.15	0.03	0.03
P2O5	0.00	0.11	0.13	0.11	0.14	0.07
S	---	0.05(SO3)	-	0.05	0.03	--
Cr2O3	0.00	--	--	0.07	0.11	--
NiO	---	--	--	0.03	0.02	--
BaO	0.00	--	--	0.007	0.02	--
LOI	42.19	1.47	17.61	1.10	5.03	0.99
Total	99.9	100.38	99.03	99.54	99.74	99.71

5. SPECTRAL ANALYSIS

The carbonates rocks under the spectral studies given spectral absorption feature near 1.83µm, 2.0µm and 2.35 µm, which are related to the existence of carbonate ion in the rock chemistry. The subtle band shift is clearly seen in the figure 3and shape of absorption is seen near the wavelength region 2.32 and 2.34µm.

The BHQ collected near Haranahalli (Atyala narasimha swami temple) exposed near the road cutting, the alternating layers of quarts and iron ore form the banded iron formation. The Hematite ore a member of Iron oxide group shows intense absorption feature in 0.55µm of the EM spectrum is clearly observed in the figure 3.

Chlorite schist collected from the location manchekatte and near vobalapura belongs to the Bababudan group of rocks, the laboratory spectra of these rocks exhibits absorption features near 2000 nm and 2400 nm due to the presence of Fe, Mg-OH ions in the figure 4.

Amphibolite in the study area mainly occurred in three forms like in traps/flow and minor intrusions, these are having close association with gneiss and quartzite and chlorite schist and third form is of para-amphibolite occurs as interlayers and patches in the chlorite schist. The intrusive amphibolite shown (figure 4) the only absorption near 1400 nm due to OH bearing mineral assemblage, the moderate absorption feature near 2300nm 2350nm is due toFe, Mg-OH absorption ions in the crystal chemistry (Basavarajappa et al 2015 and 2017).

The sample from Kalinganahalli exhibits the presence of biotite and K-feldspar in the hand specimen, the spectral absorption near 1400 nm is not narrower compare to the spectra of schistose rocks. The two 2350 and 2400 nm absorption are not distinguishable like other spectral signatures figure 5. The absorption near 2250 nm is another distinct property of micaceous mineral which varies the interpretation by expressing the absorption of Fe, Al-OH ions.

The laboratory spectra of Biotite gneiss representing the alteration from the preexisting rock shows sudden rise in the reflection near 2.25µm and 2.3 µm proven the biotite occurrences in the gneissic rock. The other silicate minerals like quartz and feldspar miner doesn't show any reflectance near VNIR-SWIR region but exhibits more response from the thermal region of electromagnetic spectrum. Figure 5 clearly shown the hydroxyl mineral occurrence and biotite mineral near 1.4µm, 2.25 and 2.32 µm absorption respectively.

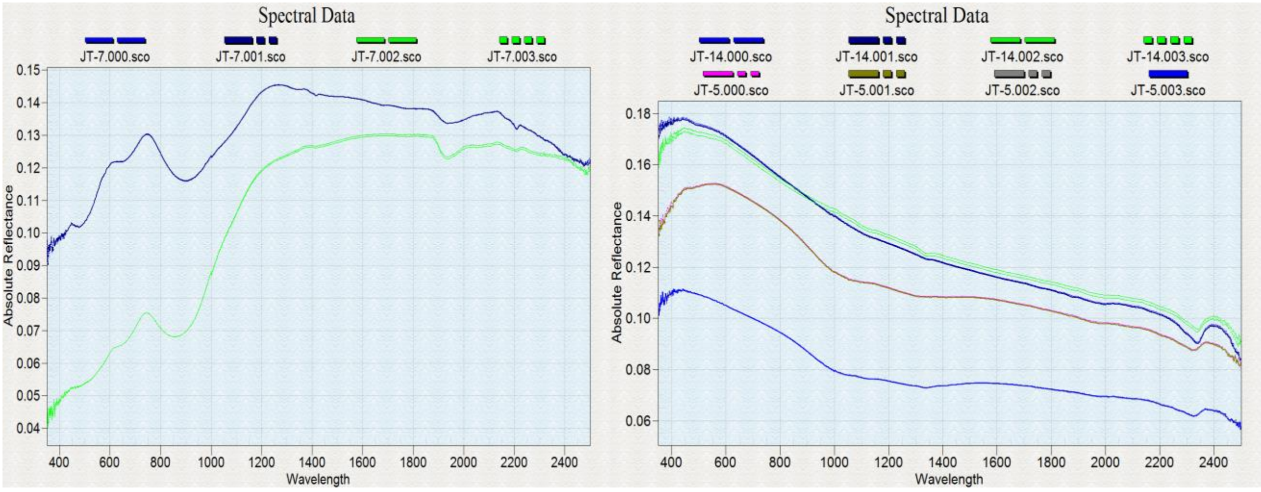

Fig.3 Laboratory spectral reflectance of Carbonate (limestone)and Hematite minerals (BIF)

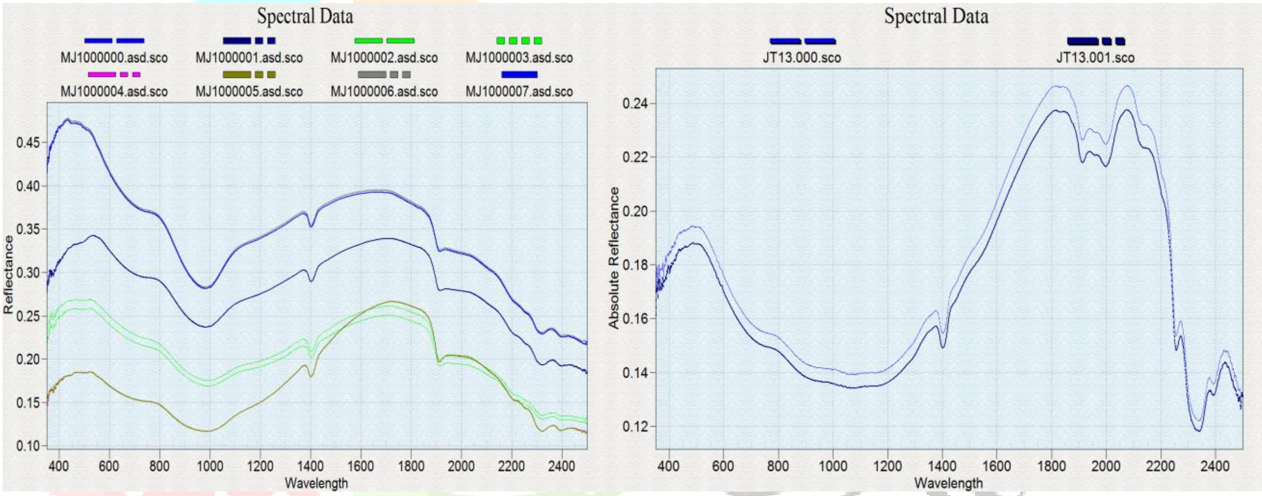

Fig.4Laboratory spectral reflectance of Chlorite Schist and Amphibolites

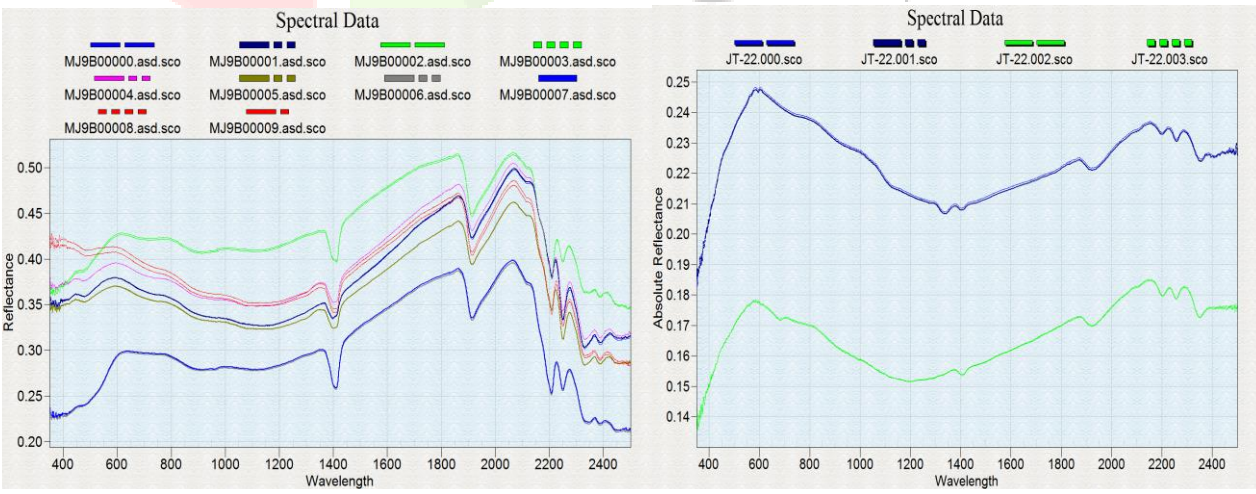

Fig.5Laboratory spectral reflectance of Muscovite schist and Biotite Gneiss

5. CONCLUSIONS

The overall spectral signature results of the spectroradiometry is best compiled with the petrography and chemical analysis of the selected rock samples of southern part of Chitradurga schist belt. Spectral signature of all the six samples are best matched with the USGS standards and the absorption features is obtained by the spectral studies are correlated with the pioneer studies and spectral signatures of Precambrian rocks of the study area. Collecting the spectral signatures of different Precambrian rocks of Chitradurga schist belt is the initial work started to build the spectral library of the Indian rock types.

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