HYPERSPECTRAL SIGNATURES AND PETRO-CHEMICAL STUDY ON STEATITE DEPOSIT AROUND VADRAHALLI VILLAGE, DHARWAR CRATON, KARNATAKA, INDIA

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Abstract

Dharwar Craton composed of large diversified litho units. The rock formations of Karnataka in the geological history are largely confined to two oldest eras the Archean and the Proterozoic, the rest of the great periods from Cambrian to resent. Most of the economical valuable mineral deposits are associated with Precambrian rocks. Steatite is a compact metamorphic rock with much of it talc mineral along with other minor impurities. Due to their unique heat resistant and other physical properties they are used in ovens, masonry heaters, fireplace liners, cookware, electronic insulator and carvings etc. Occurrences and good workable deposit of Steatite around Vadrahalli village of Hassan district have been identified and demarcated. Fresh samples of steatite, metabasalt, basic dyke and pegmatic gneiss were randomly collected in the field through GTC (Ground Truth Check). Rock samples were studied under transmitted light microscope, Reflected light microscope, SEM-EDX and Spectro-Radiometer. Spectral signatures were studied by Spectro-Radiometer (Spectral Evolution SR-3500) instrument, DARWinSP.V.1.3.0 and ArcGIS software. Petrography helped to know the minerals which are associated with steatite, SEM-EDX studies helped to know the high Mg and Cr elemental percentage present in the given steatite sample. The spectral signatures of the collected samples were derived in laboratory environment to achieve better accuracy. Spectral signature curves of steatite were derived based on their physico-chemical and optical properties. The present work is aimed for studying the petro-chemical signatures and hyperspectral signatures of steatite and their associated litho units. The final results highlight the spectral characters of steatite for mapping and demarcating the deposit in the study area and also for better mapping in similar terrains around Precambrian terrains, Dharwar Cratonic group of Karnataka State.

Keywords: Steatite**,** Petrography, Hyperspectral Signatures, SEM-EDX studies, Vadrahalli village

1. INTRODUCTION

Steatite is a massive compact often impure variety of talcose rich metamorphic rock. This rock is commonly known as soapstone because of composed largely of the mineral talc which is softest of all minerals with hardness of 1. Steatite is best known for its heat resisting characteristics therefore used widely in heaters, masonry heaters, oven floors, fireplace liners, and electronic insulators. They are also used widely for carvings, beads, etc. In India for centuries as a medium for carving this rock has been used. Occurrence of steatite deposit around Vadrahalli village have been identified and demarcated. Quite a number of geologists have worked in the area and have described the rock types and classified them. The above area comes under Sigegudda schist belt (S.P. Venkata Dasu and Aijaz Akhtar 1985). Swami Nath and Ramakrishnan(1981) who worked in these areas said that the ultramafic schist (soapstone) which occurs just to the west of the Quartz Pebble Conglomerate (Q. P. C) contains inclusions of the supposed 'basal quartzite' of Sigegudda belt.The presence of gold and uraniferous minerals is not yet established in the conglomerate of the Sigegudda belt, but the quivalent conglomerate in the Bababudan belt are known to be uraniferous (Swami Nath et. Al. 1974, Srinivas and Srinivasan, 1974, Rama Rao, 1975) and also have been investigated for copper at Kalasapura (Narasimhan and Viswanatha, 1970). A brief account of Geological, Petrological, SEM-EDX, Hyperspectral signatures studies is discussed.

2. STUDY AREA

The study area is located in between 13°7'0" to 13°9'0" North latitude and 76◦1'0" to 76◦3'0" East longitude. The area comprises linear mounds, ridges and conical hills. It falls in the toposheet number 57 C/4 in the Hassan district of Karnataka.

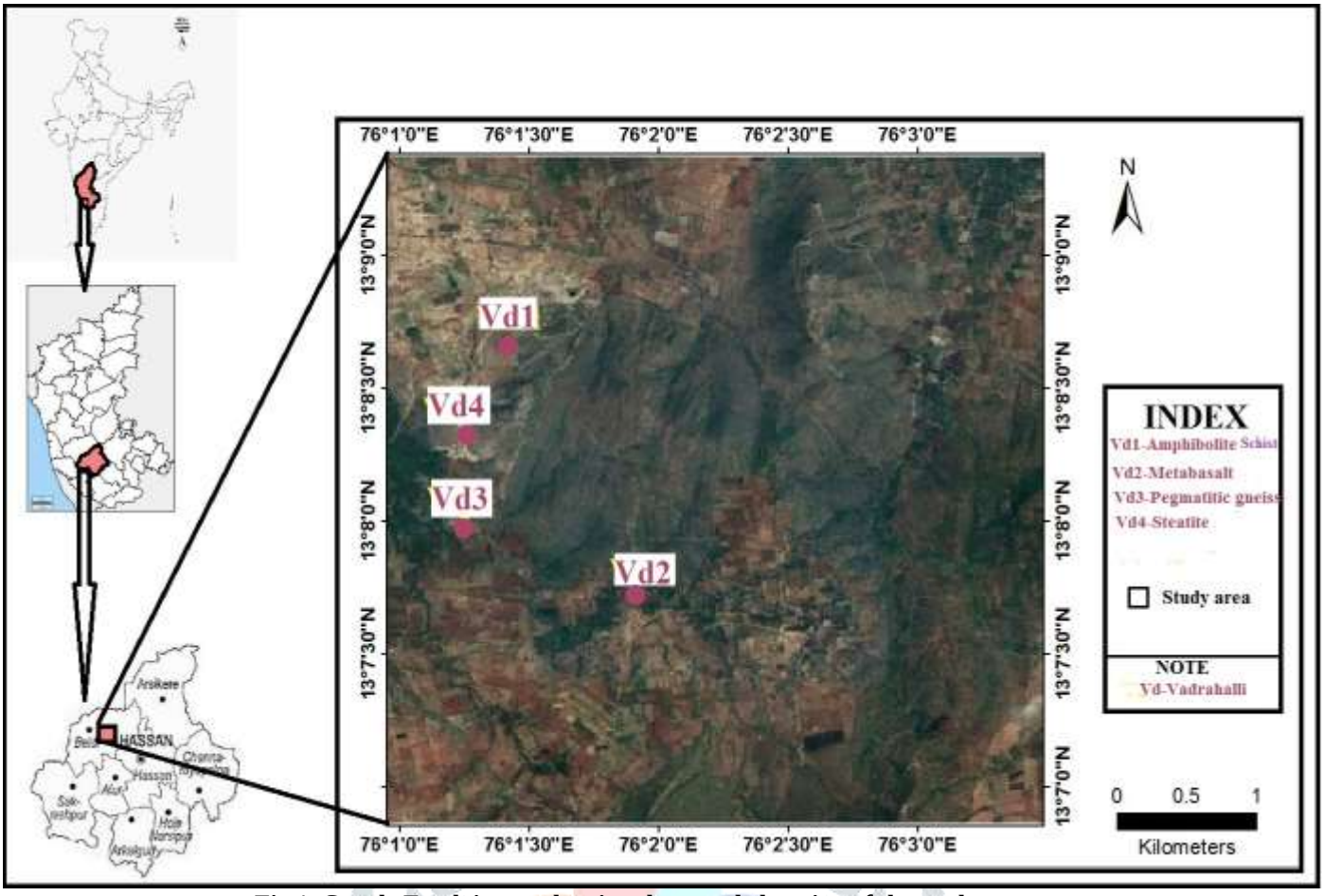

Fig.1. Google Earth image showing the sample location of the study area

Sample number	Sample Name	Location	Latitude	Longitude
Vd1	Amphibolite Schist	Vadrahalli	13°8'44.264''	76°1'25.407''
Vd2	Metabasalt	Vadrahalli	13°8'0.429''	76°1'57.906''
Vd3	Pegmatic Gneiss	Vadrahalli	13°8'0.051''	76°1'7.268''
Vd4	Steatite	Vadrahalli	13°8'22.724''	76°1'7.268''

3. GEOLOGY

The Hassan district comprises a variety of rocks (Archean to Proterozoic). The entire district consists most of the economically valuable deposits such as chromite, gold, corundum, garnet, copper, asbestos, titaniferous iron stone, uranium, vermiculite and also steatite with wide range of rock types.The study area falls under Sigegudda schist belt which is in the eastern part of Belur taluk of rocks trending in NNW-SSE direction. The Sargur Groups rocks occur to the west of the schist belt rocks and comprise amphibolites and meta-ultramafites in close association margin forms. They occur as linear bands or lenticular patches within the gneissic complex. The country rocks in the western part of the area are the gneisses in which the Sargur rocks occur as enclaves. Also there is an angular unconformirty over the peninsular gneisses with basal oligomict conglomerate. Amphibolite dikes are seen intruding in this area.

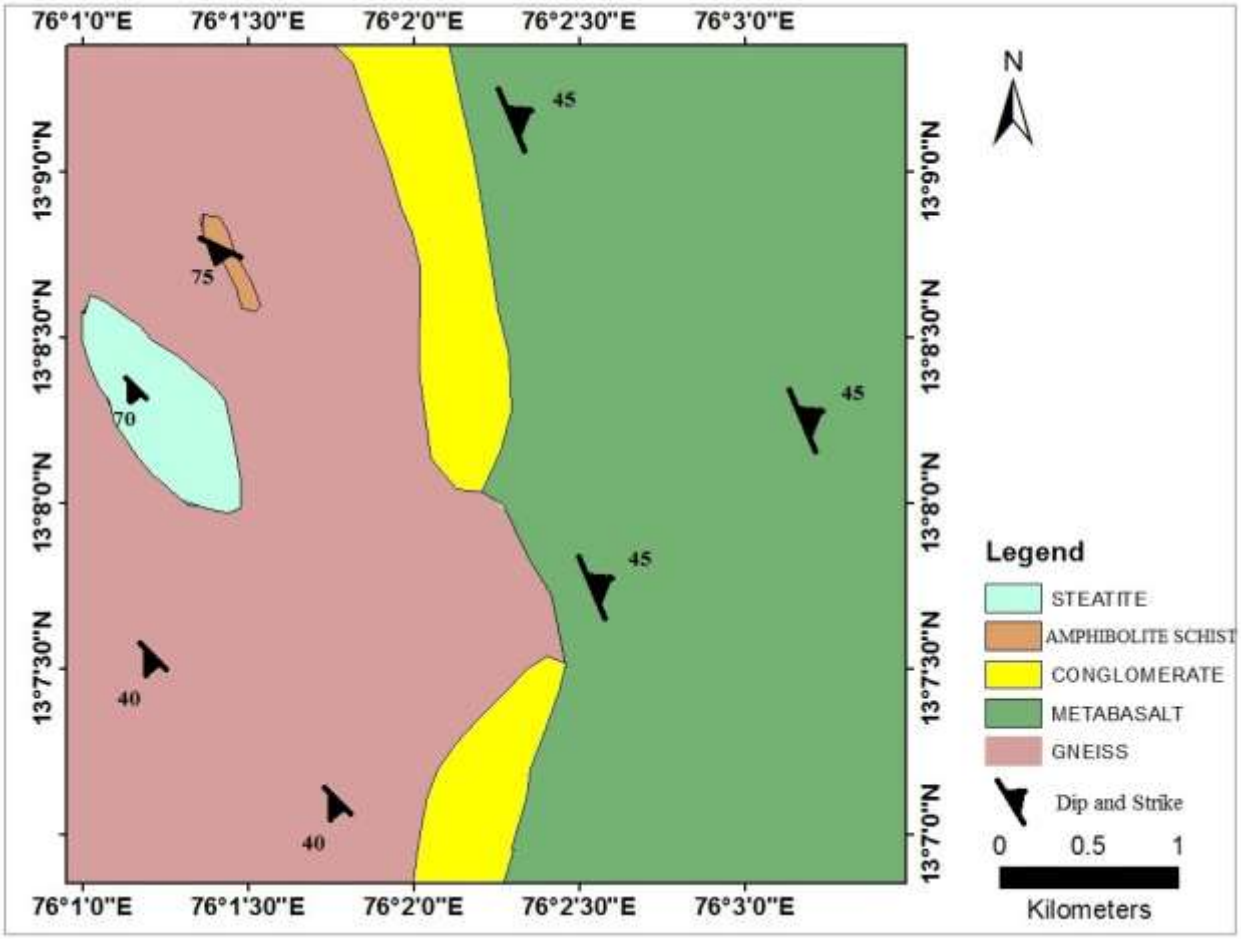

Fig. 2 Geological map of the study area (after GSI 1971)

4. METHODOLOGY

Field based samples were collected and carried carefully to the laboratory for Petrographic study.Rock Samples were studied under transmitted light microscope, Scanning Electron Microscope with Eectron Dispersive Spectroscopy (SEM-EDS) at Central instrumentation and research facility Vijnana Bhavan University of Mysore; Hyperspectral Signatures analysis for rock sample were carried out using Lab Spectro-radiometer instrument (Spectral Evolution SR-3500) at Department of Earth Science, University of Mysore, Manasagangothri, Mysuru. DARWin SP.V.1.3.0 software is well utilized in analyzing each spectral curves obtained from the collected samples (average of 4 spectral curves from each samples) and were correlated with the standard curves of USGS, JPL and JHU. Survey of India (GSI) topo map and geological quadrangle map (48o) of 1:250,000 scale is used during the field investigation to study the Steatite deposits occurring in that area, Basavarajappa et al., 2019. Garmin-72 GPS is used to record the exact locations of each sample with an error of 9 mts during field visits.

5. PETROGRAPHY

5.1. Amphibolite Schist:

The metamorphic rock mainly consisting of green, brown or black amphibole,Hornblende and plagioclase. The amphibole constitutes ≥50% of the total mafic constituents. Here amphibole has a strong pale greyish-green turning to dark greyish-green pleochroism. In between twinned plagioclase can be easily differentiated. Therefore the rock has been identified as amphibolites schist (Fig.3).

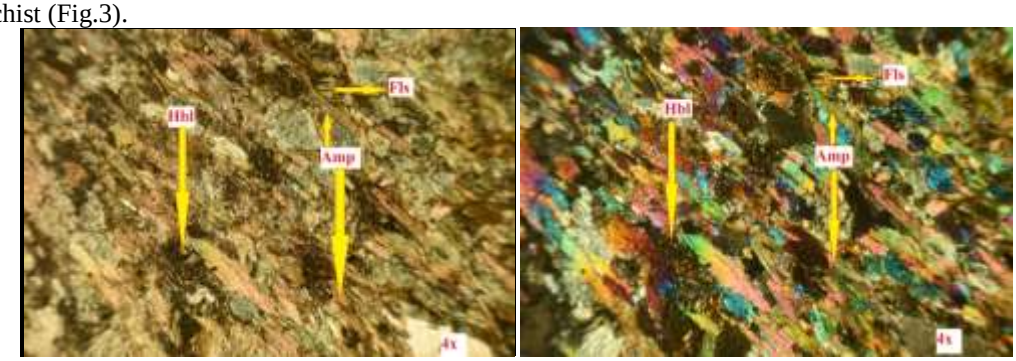

Fig. 3 Photomicrographs of Amphibolite schist under PPL and XPL

5.1. Metabasalt:

The Metabasalt mainly consisting of plagioclase feldspar. Large coloured crystals appear embedded in the fine-grained basalt matrix. Plagioclase occurs in two generations as larger phenocrysts and as small tabular to elongated groundmass. Therefore the rock has been identified as metabasalt (Fig.4).

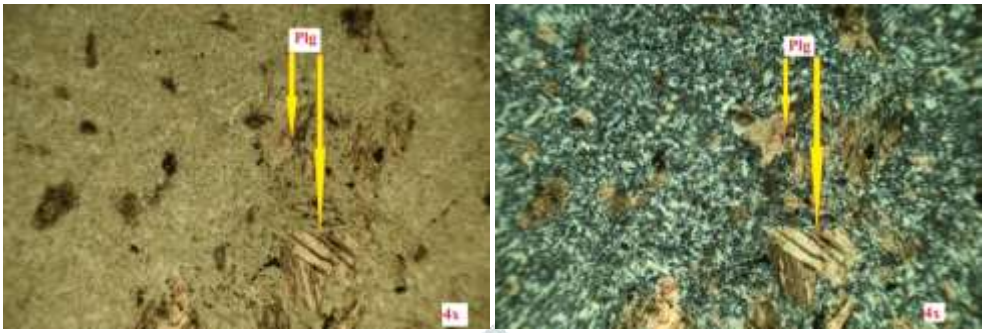

Figure.4 Photomicrographs of Metabasalt under PPL and XPL

5.1. Pegmatitic Gneiss:

The pegmatic gneiss mainly consisting of large plagioclase feldspar with small quartz and tremolite in it. The mineral under plane polarized light shows colourless, non-pleochroic with low refractive index. Tremolite occurs as needle-like laths or prismatic aggregates, pale yellow in color and exhibits faint pleochrosim. The presence of tremolite implies a relatively low grade of metamorphism. Therefore the rock has been identified as pegmatitic gneiss (Fig.4).

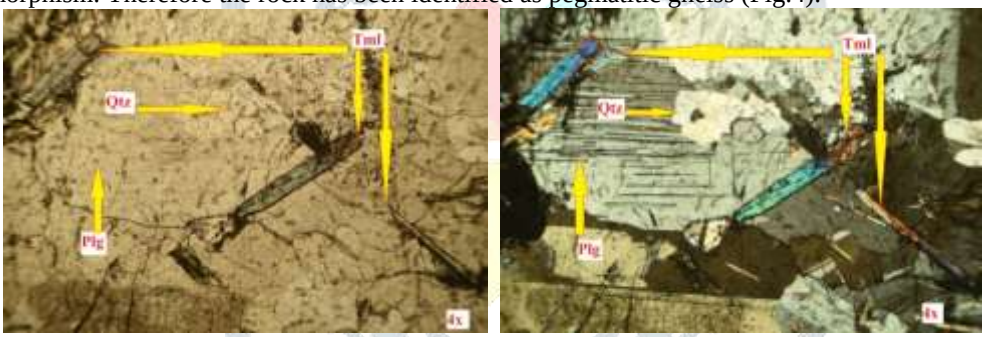

Figure.5 Photomicrographs of Pegmatitic Gneiss under PPL and XPL

5.1. Steatite:

The massive variety talc appears to be replacing the preexisting minerals in almost all the directions. The talc is bright colored (1st to 2nd order colours). Patches of pale green colored chlorite mineral can be seen along with fe oxides. With all the above observations seen the rock is identified as Steatite (Fig.5).

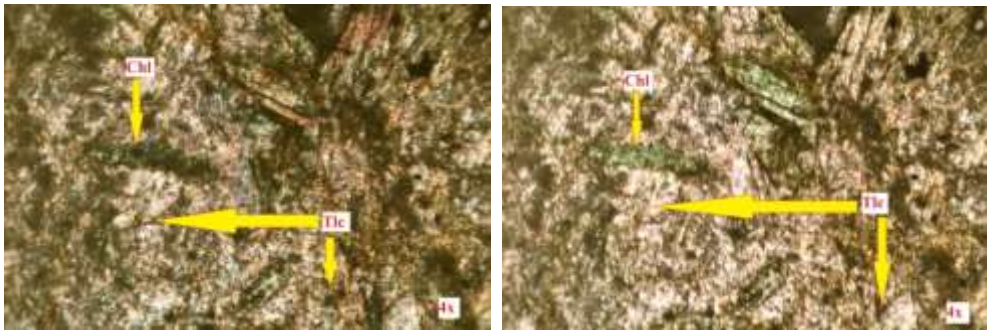

Figure.6 Photomicrographs of Steatite under PPL and XPL

6. SEM AND EDS/EDX

Scanning Electron Microscopy (SEM) magnifies a specific sample region using a high energy focused beam of electrons. The sample is under vacuum to ensure the electron beam stays focused and does not interact with particles in the air. When the beam of electrons hits the sample, it causes secondary electrons to be released from the sample which are

detected to provide an image based on the topography of the surface. The two detectors most commonly used include the Secondary Electron Detector (SED) and the Backscattered Electron (BSE) Detector. The electrons interact with the detector to create an image. SEM analysis is more powerful than Optical Microscopy not only because of the much increased magnification power but also because of the increase in depth of field (Siddaraju et al., 2019). The sample region evaluated with SEM Analysis can also be determine the specific elements that comprise the sample region by utilizing Energy Dispersion Spectroscopy (EDS). X-rays are also released from the surface of the sample that carries a unique energy signature that is specific to elements found in the sample. These X-rays are detected with the EDS detector to give elemental information about the sample. EDS provides data about the chemical composition of the sample and provides additional data about the features that are observed in the SEM microphotographs. This combined technique is referred to as SEM-EDS or SEM-EDX analysis (PinakiSengupta et al., 2008). The SEM-EDX analysis is as shown in (Fig.8, 9 and Table1).

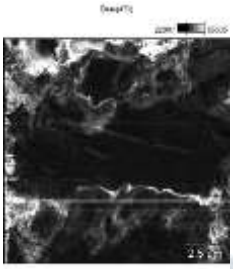

Fig.8 SEM image data of steatite

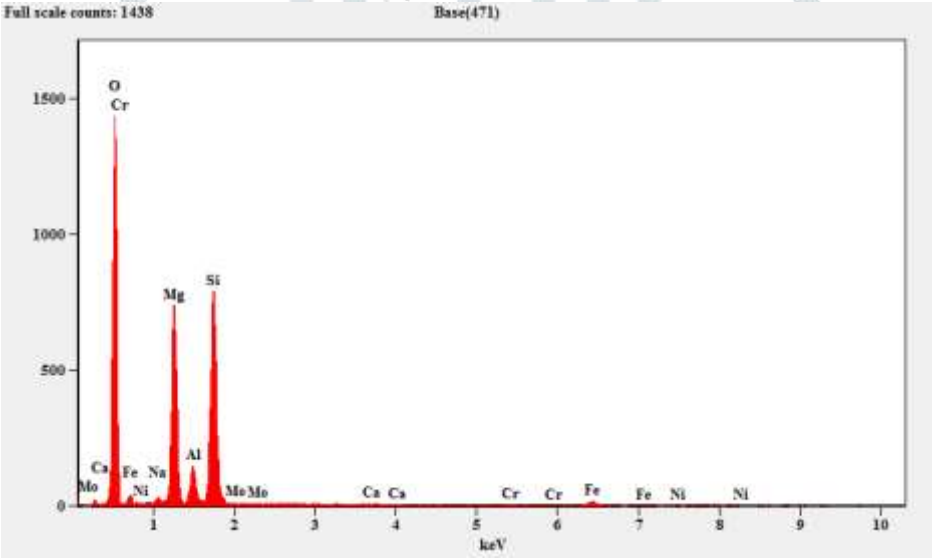

Fig.9 Typical EDX spectrum: y-axis depicts the number of counts and x-axis the energy of the X-rays. The position of the peaks leads to the identification of the elements and the peak height helps in the quantification of each element's concentration in the sample.

Table-1: Showing elemental analysis of Steatite

Element Line	Weight %	Weight % Error	Atom %
O K	59.09	± 0.50	70.81
Na K	2.31	± 0.40	1.93
Mg K	16.06	± 0.33	12.67
Al K	2.02	± 0.41	1.44
Si K	17.99	± 0.30	12.28
Si L	---	---	---
Ca K	0.13	± 0.07	0.06
Ca L	---	---	---
Cr K	0.12	± 0.11	0.04
Cr L	---	---	---
Fe K	2.06	± 0.41	0.71
Fe L	---	---	---
Ni K	0.14	± 0.20	0.05
Ni L	---	---	---
Mo L	0.09	± 0.15	0.02
Mo M	---	---	---
Total	100.00		100.00

Energy Dispersive X-ray Spectroscopy (EDS) as an analysis method the steatite rock contains the presence of elements like O, Mg, Al, Si, Ca, Cr, Mo, Na, Fe and Ni were determined. Here mainly concentrate of Mg presence is in 16.06%.The elemental analysis photographs of individual elements of steatite rock is as shown below (Fig.10).

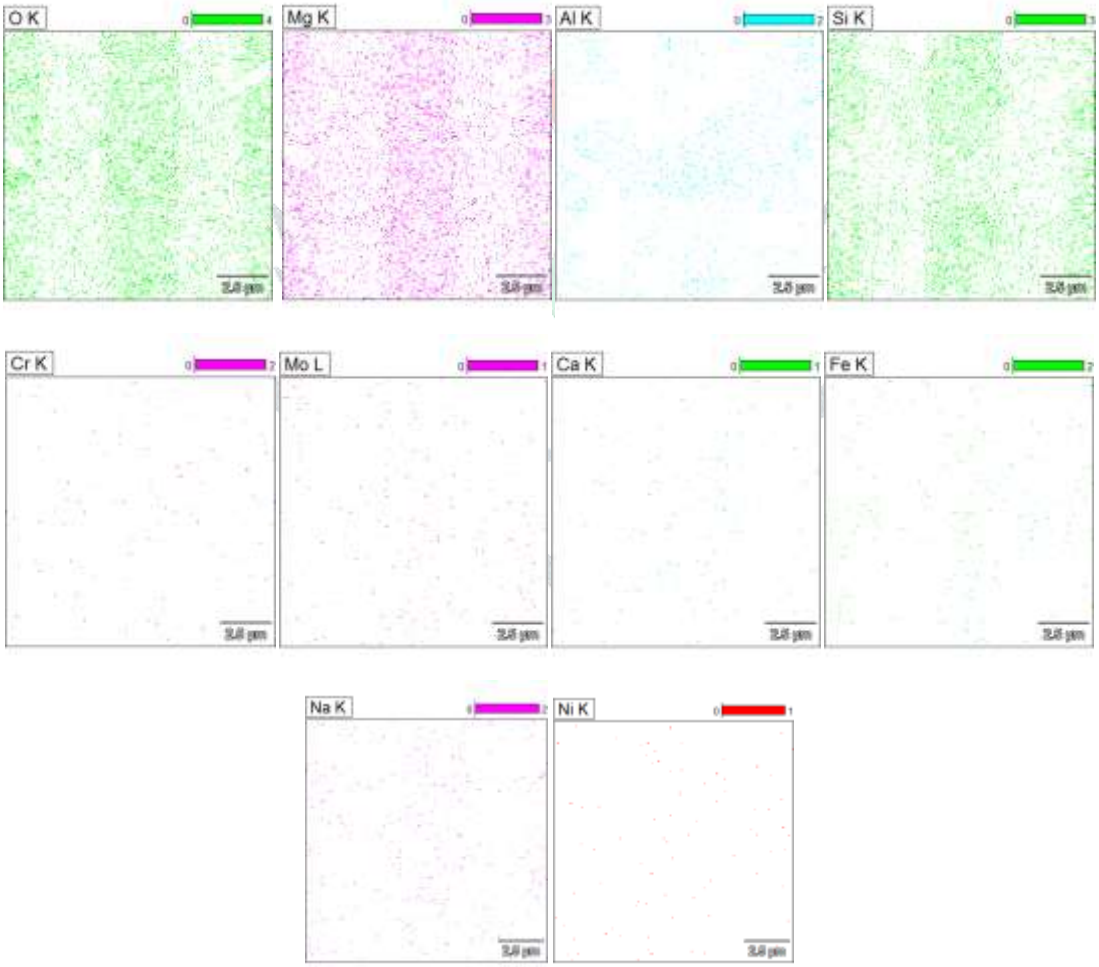

Figure 10. EDX image analysis of individual elements of steatite

SEM-EDX studies helped to know the high Mg elemental percentage present in the given steatite sample. Also presence of nickel suggests that the steatite have been formed from mafic-ultramafic rock which is erupted and formed from deep seated magma occurring around Vadrahalli village.

7. HYPERSPECTRAL SIGNATURES

Spectral signature measures all types of wavelengths that reflect, absorb, transmit and emit electromagnetic energy from the objects of the earth surface (Ali M. Qaid et al., 2009) (Basavarajappa et al., 2018). Specral Evolution (SR-3500) Spectro-radiometer instrument has the ability to measure the spectral signatures of different rocks/ minerals. The SR-3500 operate in the wavelength range of 350–2500 nm with three detector elements: a 512-element Si PDA (Photo Diode Array) covering the visible range and part of the near infrared (up to 1000nm) and two 256-element In GaAs arrays extending detection to 2500nm. The spectral signatures of the representative samples were compared with mineral spectra of USGS spectral library in DARWin SP.V.1.3.0 (Hunt et al., 1971). Absorption spectral values obtained from the DARWin software lab Spectra is the one character helps in the study of major and minor mineral constituents (Maruthi et al., 2019, Abrar Ahmed et al.,2019).

8. RESULT AND DISCUSSION

The Spectral signature curves of Steatite rock were derived are as shown below with description:

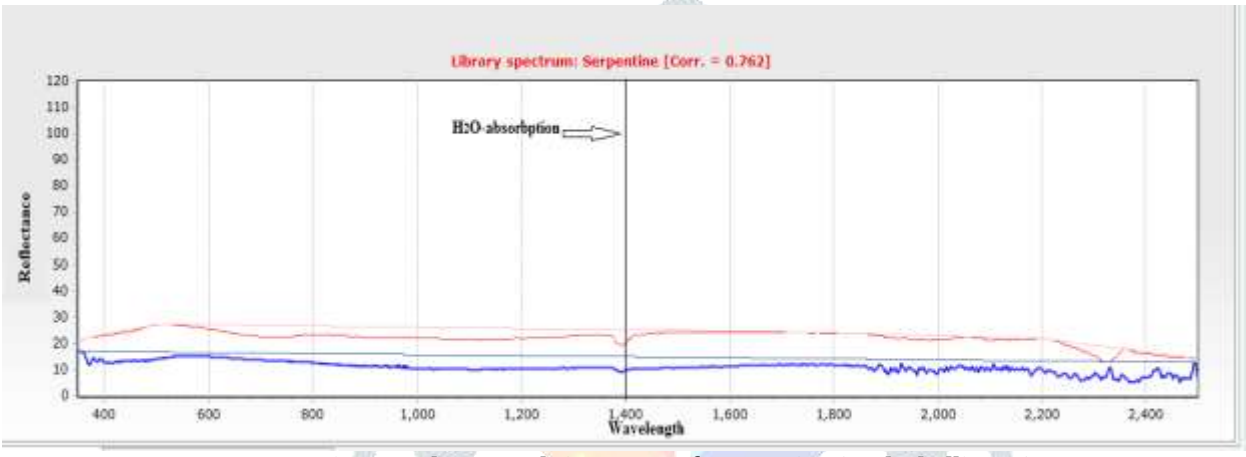

Fig. 11 Lab Spectral signatures of Serpentine (Vadrahalli area).

The spectrum is of serpentine. Serpentine is a hydrous secondary mineral, typically an alteration product of olivine, pyroxene, or amphibole. Weak ferric and ferrous ion bands are displayed by this sample near 0.7 and 1.0µ respectively, which may be original, or due to the presence of a small amount of unaltered amphibole. The bands near 1.4µ and at wavelengths longer than 1.9µ are hydroxyl bands. Library spectrums of Talc correlation score 0.762 percent match the curve (Fig.11).

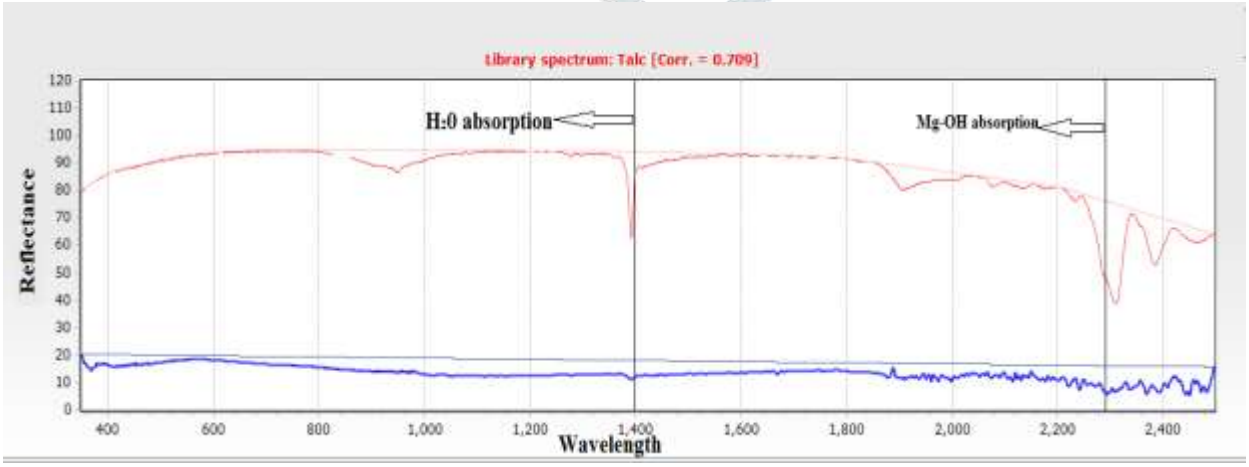

Fig. 12 Lab Spectral signatures of Talc (Vadrahalli area).

The spectrum has characteristic talc features at 2.3 microns with high Magnesium percent. They show Intense, narrow basal reflections with excellent resolution. These samples are intimate mixtures of various minerals associated with hydrothermal alteration. Library spectrums of Talc correlation score 0.788 percent match the curve (Fig.12).

Table-2: XRD-ANALYSIS

Oxide	Weight Percent, %
SiO_2	58.38
TiO_2	0.03
Al_2O_3	0.18
FeO	0.22
MnO	0.56
MgO	31.90
ZnO	0.03
BaO	0.00
CaO	0.65
Na_2O	0.17
K_2O	0.01
Cl	0.01
F	0.25
Total	92.29

Field geological map showing both eruption and upliftment has taken place. Conglomerate which are in the middle of ultramafics, gneiss on one side and metabasallt on other side. Ultramafics, gneiss dipping towards west side and metabasalt dipping towards east side. Due to burial metamorphism in in the lower level of lithosphere the unconformity is developed which are showing conglometrates beds which are metamorphosed in between high grade metamorphic rocks (Fig.2).

Field photographs:

Fig.12 Field photograph of steatite (Vadrahalli village).

Fig.13 Field photograph of steatite (Vadrahalli village).

Fig.14 Field photograph of steatite showing pitted appearance (Vadrahalli village).

10. CONCLUSION

The steatite deposit around Vadrahalli village which comes under Sigegudda schist belt have been identified and demarcated. Geological, Hyperspecral signatures, SEM-EDS analysis, and Petrographic studies help to find out Physical and Chemical characteristics. Geological studies helped to understand the field setup of the steatite deposit with their associated lithounits which is showing high elemental concentrations of Mg, Cr and Ni were brought from the deep seated magma in the study area. During that time high grade metamorphic deformation with shallow level upliftment of the conglomerates have occurred. Petrography helped to know the other minerals which are associated with steatite like chlorite along with other sulfides. SEM-EDX studies helped to know the high Mg and Cr elemental percentage present in the given steatite sample with minor Ni and Mo. Lab spectra of Steatite with minerals like Serpentine, talc were identified and absorption curve matches the USGS standard shows the purity of mineral present in the rock. From the above analysis done it may be said that the steatite have been formed from Hydrothermal fluids which interact with the other minerals like serpentine to form talc which may be from mafic to ultramafic in origin.

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