PHYSICO-CHEMICAL CHARECTERISTICS AND HYPERSPECTRAL SIGNATURES ON STEATITE DEPOSIT AROUND ANDALE VILLAGE, DHARWAR CRATON, KARNATAKA, INDIA

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Abstract

Steatite occurrence and deposit around Andale village have been identified and demarcated. Steatite (or Soapstone) is a compact, often impure variety of talc. Steatite is widely being used as industrial natural resource material due to good workability and heat retention characteristics. It is used in cookware, cook tops, oven floors, masonry heaters, fireplace liners, carvings, beads, mold and electronic insulator etc. Precambrian rocks of Karnataka hosts many economic valuable mineral deposits in that steatite is one among them. Fresh samples of steatite and Peninsular gneiss were randomly collected in the field through GTC (ground truth check). Rock samples were studied under transmitted 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 other minerals which are associated with steatite, SEM-EDX studies helped to know the high Mg 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 and other samples were derived based on their physico-chemical and optical properties. The final results highlight the spectral characters of steatite for better mapping in similar terrains around Andale village of Hassan district of Karnataka State.

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

1. INTRODUCTION

Steatite is a type of metamorphic rock. Steatite is compact often impure variety of talc (hydrated magnesium silicate). Steatite is also called as soapstone composed largely of the magnesium rich mineral talc which is softest of all minerals with hardness of 1. Steatite along with talc also includes minerals like carbonate, tremolite, serpentine and other minerals. Steatite is widely being used as industrial natural resource material due to good workability and heat retention characteristics which is used in cookware, cook tops, oven floors, masonry heaters, fireplace liners, carvings, beads, mold and electronic insulator etc.Soapstone has been used in India for centuries as a medium for carving. 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 spectral signatures of the field samples were compared with mineral spectra of USGS spectral library to record the spectral behavior (Basavarajappa and Maruthi, 2018). The absorption and reflection features were studied as described by Hunt and Salisbury (1970), Hunt et al., (1971), Hunt and Ashley (1979) and Blom et al., (1980). A brief account of Geological, Petrological, SEM-EDX, Hyperspectral signatures studies is discussed.

2. STUDY AREA

The study area is located in between 13°5'0" to 13°10'0" North latitude and 75◦55'0" to 76◦0'0" East longitude. It falls in the toposheet number 480/16. The general elevation is of 912 mts above MSL. The main soil types are Red soil, Red sandy soil and silty clay soil.

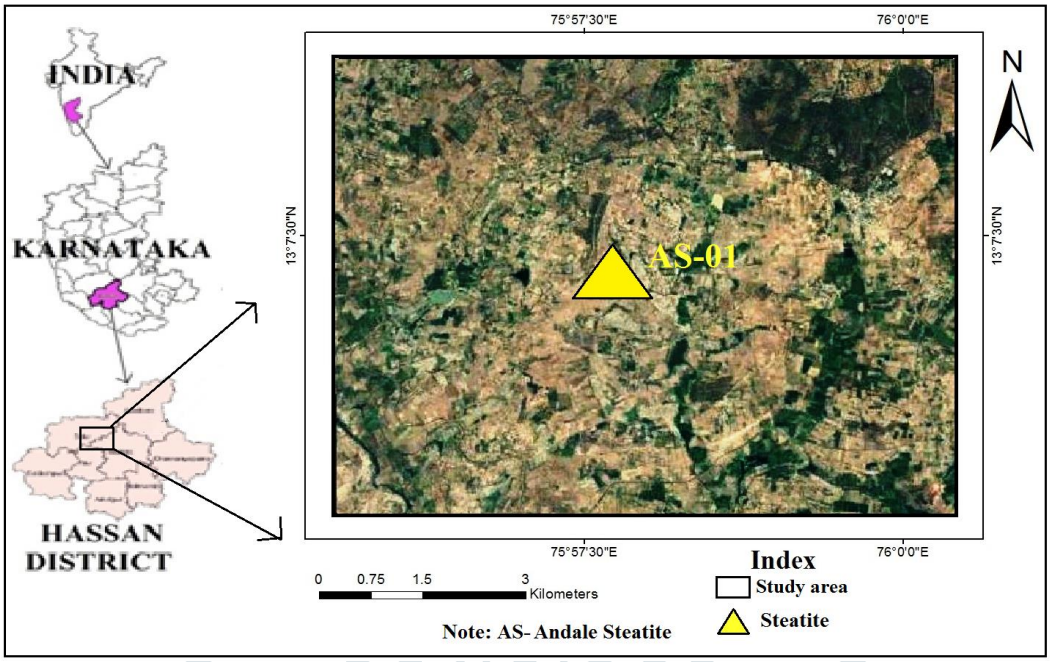

Fig.1. Google Earth image showing the sample location of the study area

Sl No	Sample Name	Location	Latitude	Longitude
1	Steatite	Andale	13°07'18"	75°57'23"

3. GEOLOGY

The study area is in the eastern part of Belur taluk of NNW-SSE trending rocks. The Hassan district comprises a variety of rocks (Archean to Proterozoic).1.Charnokites occurring as narrow linear bands in the southwestern part of the district. 2. Oldest group of supra crustal rocks as high grade schists (Sargur Group) occurring as major enclaves and well defined schist belts (Nuggihalli and Holenarsipur) within the peninsular gneissic complex. 3. Peninsular gneissic complex as the low lying plain area covering major part of the district. 4. Greenstone belt of Bababudan Group (Dharwars) as narrow linear chain of hills predominantly with NNW-SSE trends in the central and northern part. 5. Exposures of intrusive granites; Arsikera and Banavar granites correlated to closepet granite occur as hills. 6. Youngest litho units are swarms and basic dykes cutting across all the rocks spread throughout the area. The high grade schists of Sargur group are represented by mafic-ultramafic complex, serpentine, pilitic schists such as kayanite-sillimanite, staurolite, corundum-garnet-mica schist, fuchsite-sericite-quartzite, quartzite, quartz schist and banded iron formation. The ancient supracrustals of the district are endowed with a variety of mineral occurrences which includes asbestos, beryl, chromite, copper, clay, corundum, garnet, gold, kayanite, mica, sillimanite, vanadiferous-titanomagnetite, vermiculite, uranium minerals and steatite (soap stone). In Andale village most of the study area having soil cover with very few out crops commonly two rock types exposed gneiss and dolerite dykes.

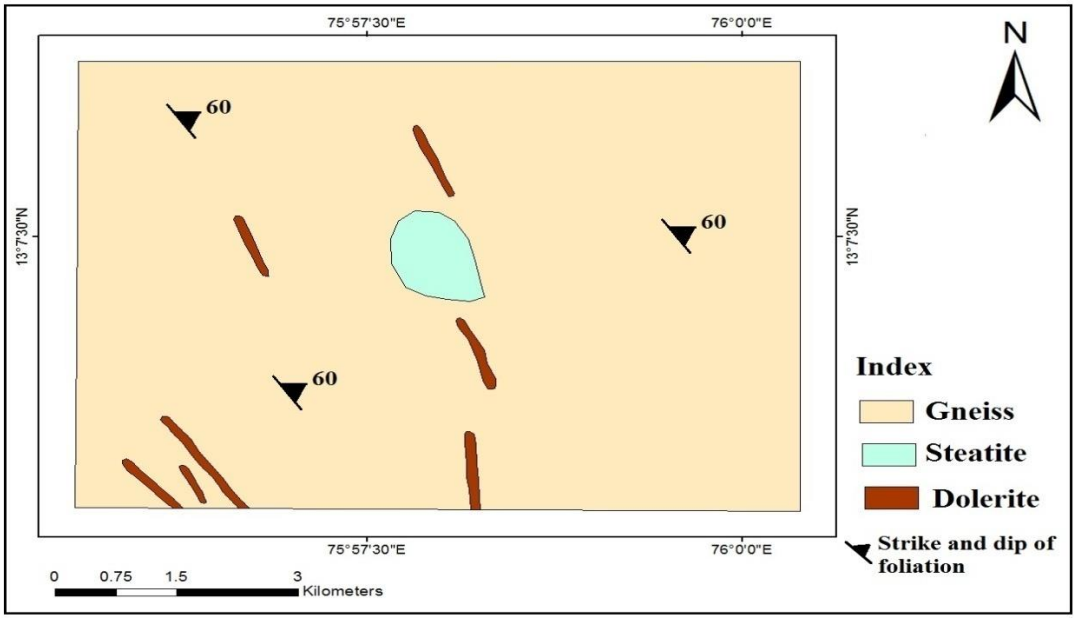

Fig. 2 Geological map of the study area with sample Locations (after GSI 1965)

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. Steatite

In this sample the massive fine grained talc appears to be replacing. The talc is bright coloured (1stto 2ndordercolors) and Petrographic image of talc showing the variation of colour in plain-polarized light verses cross-polarized light (Fig.3). It is also seen that the talc is surrounded by Fe and Cr. Actinolite occurs as needle-like laths or prismatic aggregates, pale yellow in color and exhibits faint pleochrosim (Fig 4).

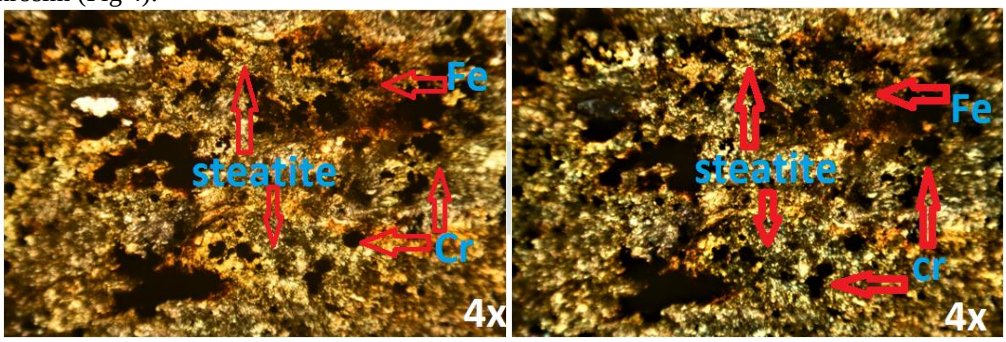

Fig. 3 Photomicrographs of Steatite under PPL and XPL.

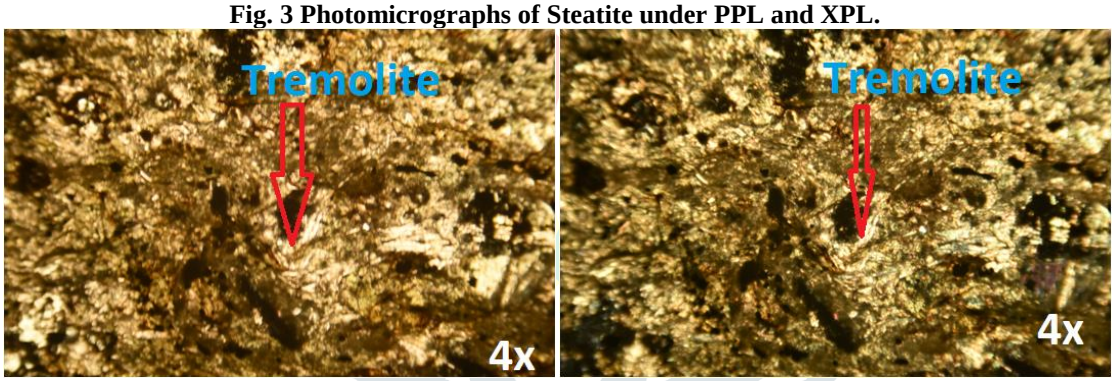

Figure.4 Photomicrographs of steatite under PPL and XPL

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 analyzed to 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 and Fig.9).

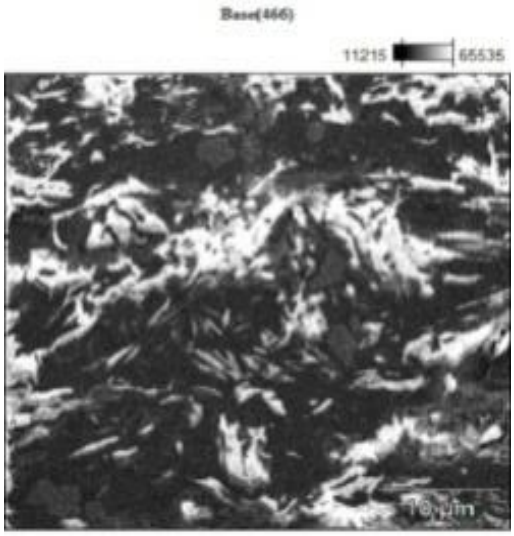

Fig.8 SEM image data of steatite

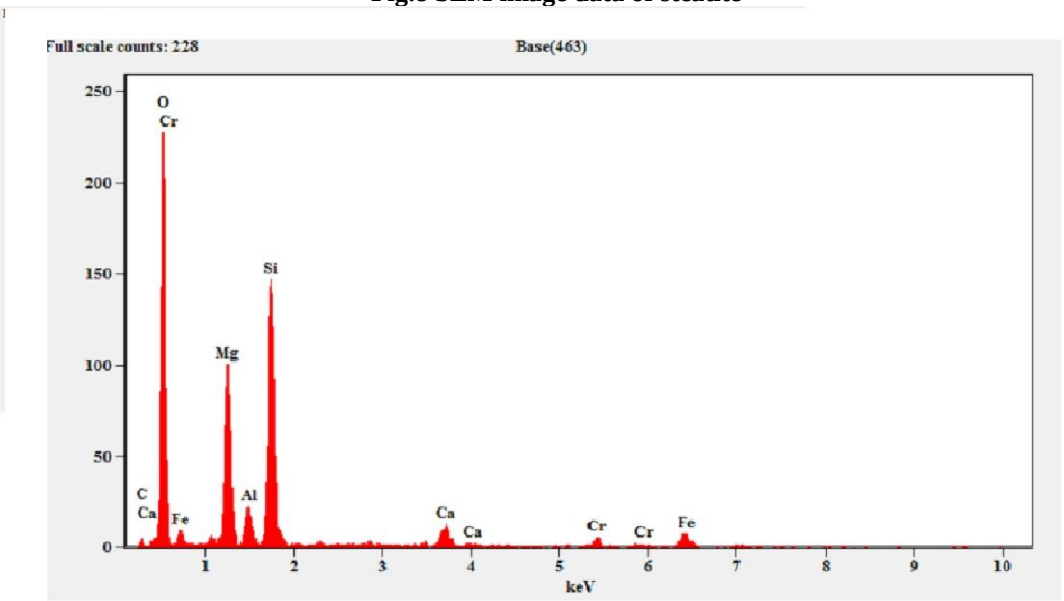

Fig.9 Typical EDX spectrum: y-axis depicts the number of counts and x-axis the energy of the X-rays. The position of the peaks leads to the identification of the elements and the peak height helps in the quantification of each element's concentration in the sample.

Quantitative Results for: Base(463)

Element Line	Weight %	Weight % Error
C K	9.81	± 1.25
O K	55.24	± 1.11
Mg K	9.65	± 0.47
Al K	2.25	± 0.27
Si K	13.76	± 0.50
Si L	---	---
Ca K	2.31	± 0.22
Ca L	---	---
Cr K	1.77	± 0.32
Cr L	---	---
Fe K	5.20	± 0.64
Fe L	---	---
Total	100.00	

Energy Dispersive X-ray Spectroscopy (EDS) as an analysis method the steatite rock contains the presence of Cr, Mg, Al, Si, O, C, Ca, and Fe were determined. Here mainly concentrate of Mg presence is in 0.12 %.The elemental analysis photographs of individual elements of steatite rock is as shown below(Fig.10)

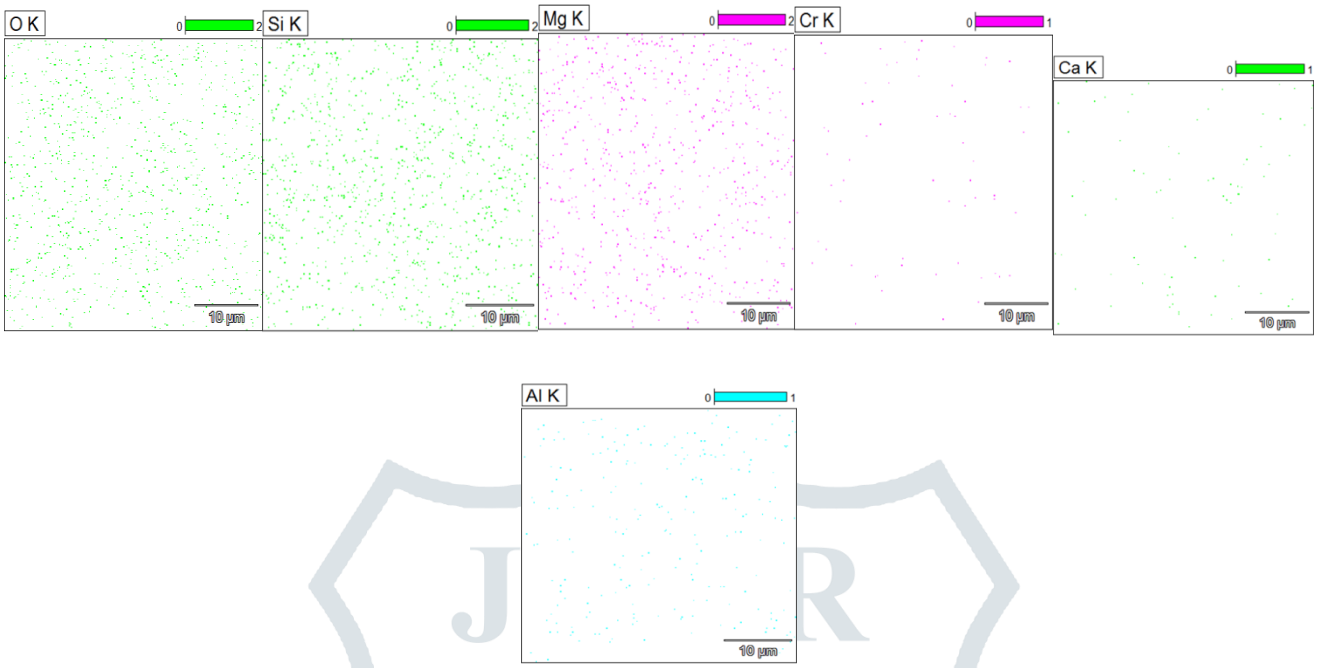

Figure 10. EDX image analysis of individual elements of steatite

SEM-EDX studies helped to know the high Mg elemental percentage present in the given steatite sample. From the above analysis the steatite have been formed from mafic-ultramafic rock which is erupted and formed from deep seated magma occurring around Andale 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:

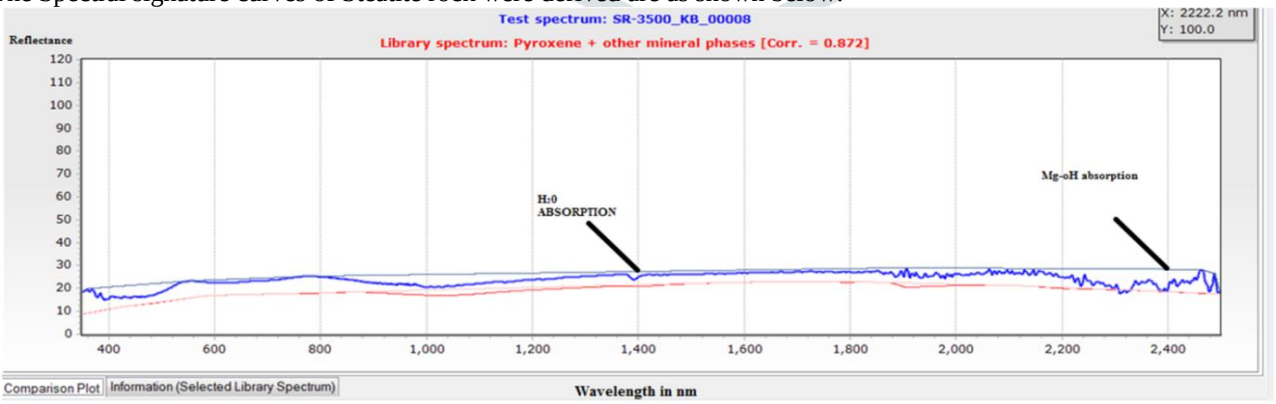

Fig. 10 Lab Spectral signatures of Pyroxene (Andale area).

The spectrum has characteristic absorptions from pyroxene at 1.0391 microns with very weak absorptions from hydrated phases (clays?) at 2.2057 and 2.3113 microns. Library spectrums of Pyroxene correlation score 0.872 percent match the curve (Fig.10).

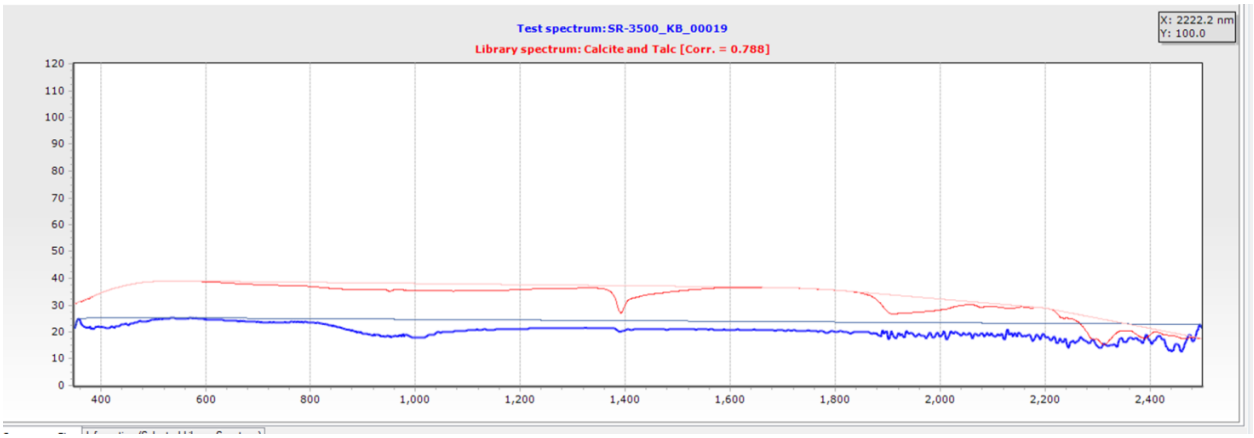

Fig.11 Lab Spectral signatures of Calcite and Talc (Andale area).

The spectrum has characteristic Strong carbonate and talc features at 2.3 microns. These samples are intimate mixtures of various minerals associated with hydrothermal alteration. Library spectrums of Calcite and Talc correlation score 0.788 percent match the curve (Fig.11).

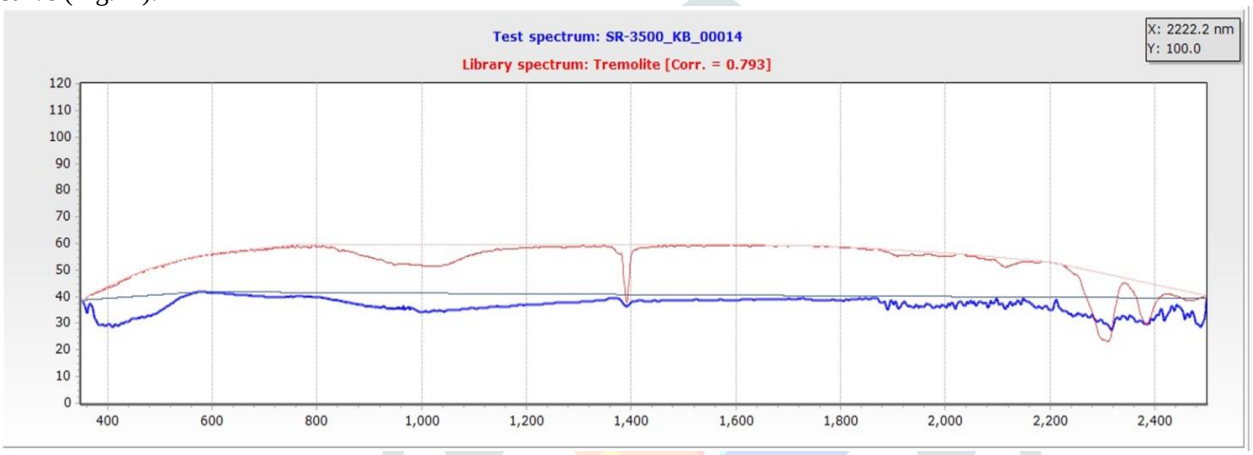

Fig.12 Lab Spectral signatures of Tremolite (Andale area).

The spectrum of sample has a fairly prominent broad band near 1µ, indicating that it contains some ferrous ion. It displays a very sharp band at 1.4µ, and less sharp bands between 2.0 and 2.5 µ due to the overtone and combination tones of the OH stretch, respectively. Library spectrums of Tremolite correlation score 0.793 percent match the curve (Fig.12).

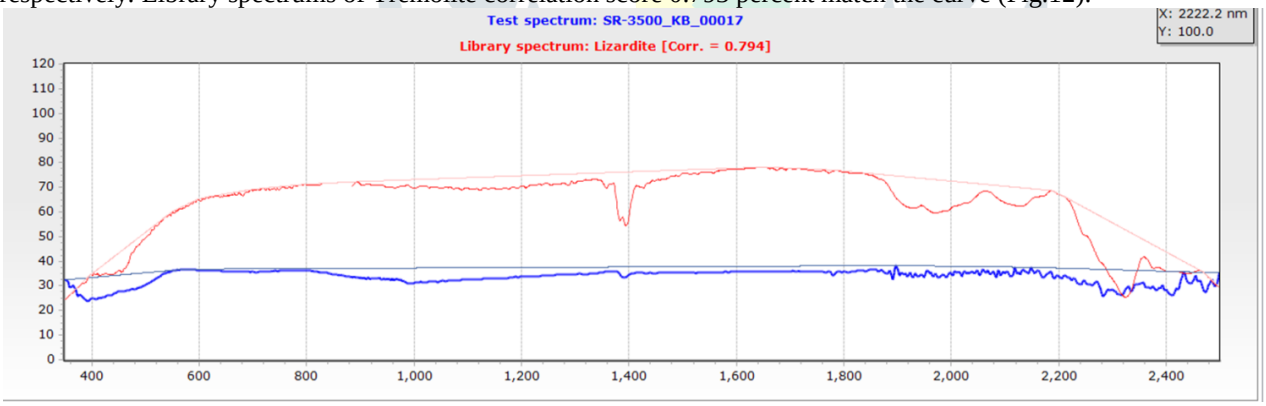

Fig.13 Lab Spectral signatures of Lizardite (Andale area).

This is an isochemical end member Mg-rich serpentine. Library spectrums of Lizardite correlation score 0.794 percent match the curve (Fig.13).

Fig.14 Field photograph of steatite (Andale area).

10. CONCLUSION

Hyperspecral signatures, SEM-EDS analysis, and Petrographic studies help to find out Physical and Chemical characteristics. Petrography helped to know the other minerals which are associated with steatite, SEM-EDX studies helped to know the high Mg elemental percentage present in the given steatite sample. Lab spectra of Steatite with minerals like pyroxene, tremolite, talc+calcite, lizardite 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 mafic-ultramafic deep seated lower hot magma. During the upliftment due to Hydrothermal fluids which interact with the other minerals like pyroxenes and carbonates associated with chromite rich alterations.

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