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Elemental Mapping, Hyperspectral Signatures And Petro-Chemical Signatures Study On Steatite Deposit Occuring Around Doddenahalli Village, Bageshpura Area, Hassan District, Karnataka

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ABSTRACT
Steatite deposit around Doddenahalli village which is close to Bageshpura have been identified and demarcated. Steatite which is also called as soapstone is a rock with major talc mineral showing massive in texture. They are usually formed from the alteration of deep seated ultramafic rocks. They have industrial and commercial uses. They are used mainly for carving and sculptures. They have special property that can resist and retain high heat so the other uses are in making electronic insulators, ovens, masonry heaters, fireplace liners, cookwares, etc. The investigated area forms part of the Archean –Greenstone Terrain (AGT) in the western part of the Dharwar Craton (WDC). Steatite in the study area occurs as enclave in the banded gneiss trending in NNW-SSE to NW-SE direction. The present study aims to examine and to study the minerals which are associated with steatite by Petrography, Scanning Electron Microscopy (SEM-EDX) and Hyperspectral Signatures. Petrography helped to know the minerals which are associated with steatite, SEM-EDX studies helped to know the high Mg elemental percentage present along with elemental mapping of different elements present in the given steatite sample. Spectral signatures of rock sample were derived and studied by Spectro-Radiometer instrument to know the purity of minerals which are present in steatite. From the above studies carried out it suggests that steatite around Doddenahalli village is an important economic non-metallic mineral deposit.

KEYWORDS: *Steatite, Elemental mapping, Hyperspectral Signatures, Doddenahalli village*

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I. INTRODUCTION

Soapstone is geochemically characterized as steatite (Baron et al. 2016),(Damick and Woodworth 2015), (Jones et al. 2007). Steatite is a soft rock which is easily carvable, dense, durable and heterogeneous rock. It is formed with processes known as metamorphosis and metasomatism by combining talc deposits with other minerals showing massive in texture. The talc is a naturally occurring mineral and composed of hydrous magnesium silicate. Steatite has lot of industrial uses. They are used mainly for carvings. They have special property that can resist and retain high heat so the other uses are in making electronic insulator, ovens, masonry heaters, fireplace liners, cookware, etc (Gokce et al. 2011), (Hand 2020), (Reynard et al. 2008). Occurrences of steatite deposit around Doddenahalli village which is close to Bageshpura have been identified and demarcated. The other rock types include actinolite tremolite schist and banded gneiss. Kaolinite and steatite are the important economic non-metallic minerals that occur in the study area (Jamal Anwar et al. 2016).

II. METHODS

Field based rock samples like steatite and banded gneiss of the present study area around Doddenahalli village were collected and analysed. Petrography, Scanning Electron Microscopy (SEM-EDX) and Hyperspectral Signatures were studied to understand the exact minerals and elements present in the rock sample. The analysis of rock samples were done at Department of Earth Science (Centre for Advanced Studies in Precambrian Geology) and Vignana Bhavan of University of Mysore, Mysore.

GEOLOGY

Hassan district geologically hosts much of older Precambrian rocks which consist of varied economic mineral deposits. Around Bageshapura area rock types are broadly divided into meta-sedimentaries, meta-ultramafics, peninsular gneiss and younger intrusives. The study area consists of rock types like steatite and gneiss. Steatite occurs as enclaves in the gneiss. The gneiss are the main rock types occurring in the area. In

hand specimen the steatite is massive in nature with sulfide mineralization. Much of the exposed steatite in the field is showing pitted appearance because of its weathering. Joints are noticed in gneiss trending in different directions. The geological map of the study area is as shown below (Fig.1).

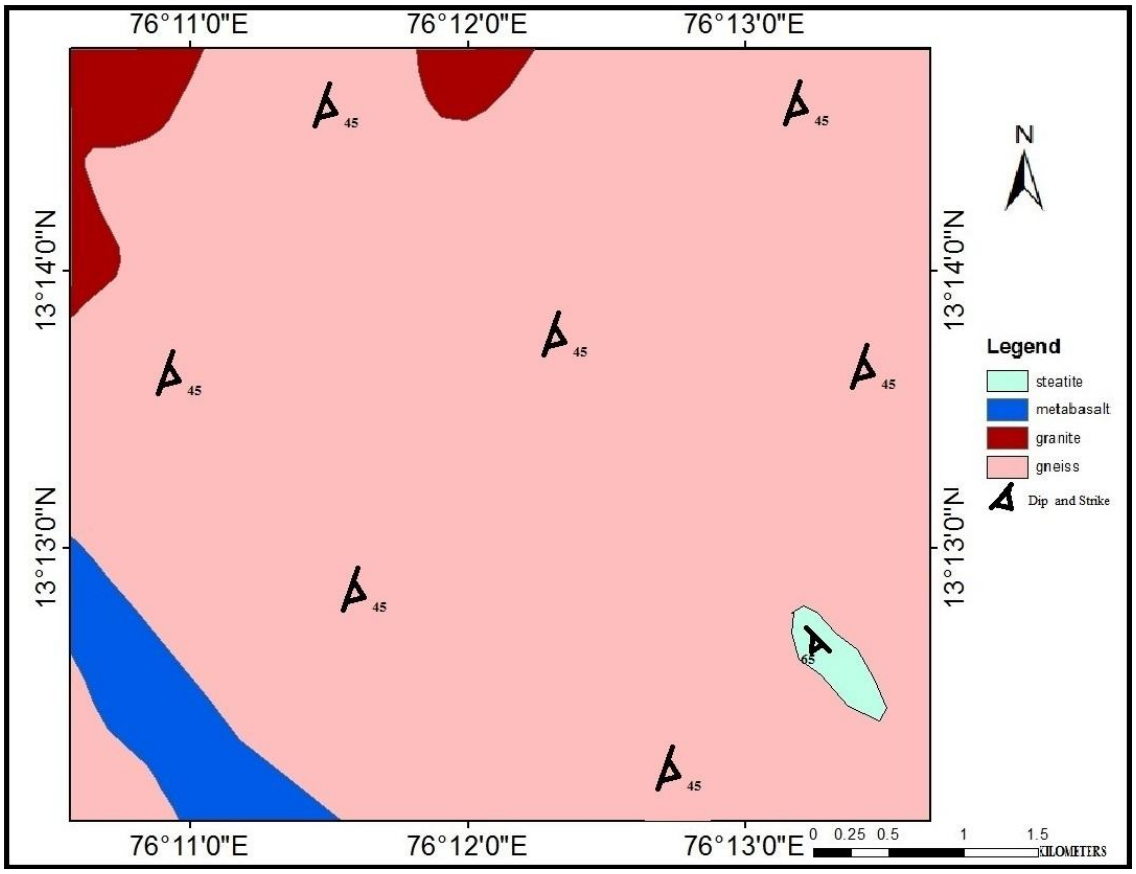

Fig.1. Geological map of Doddenahalli area.

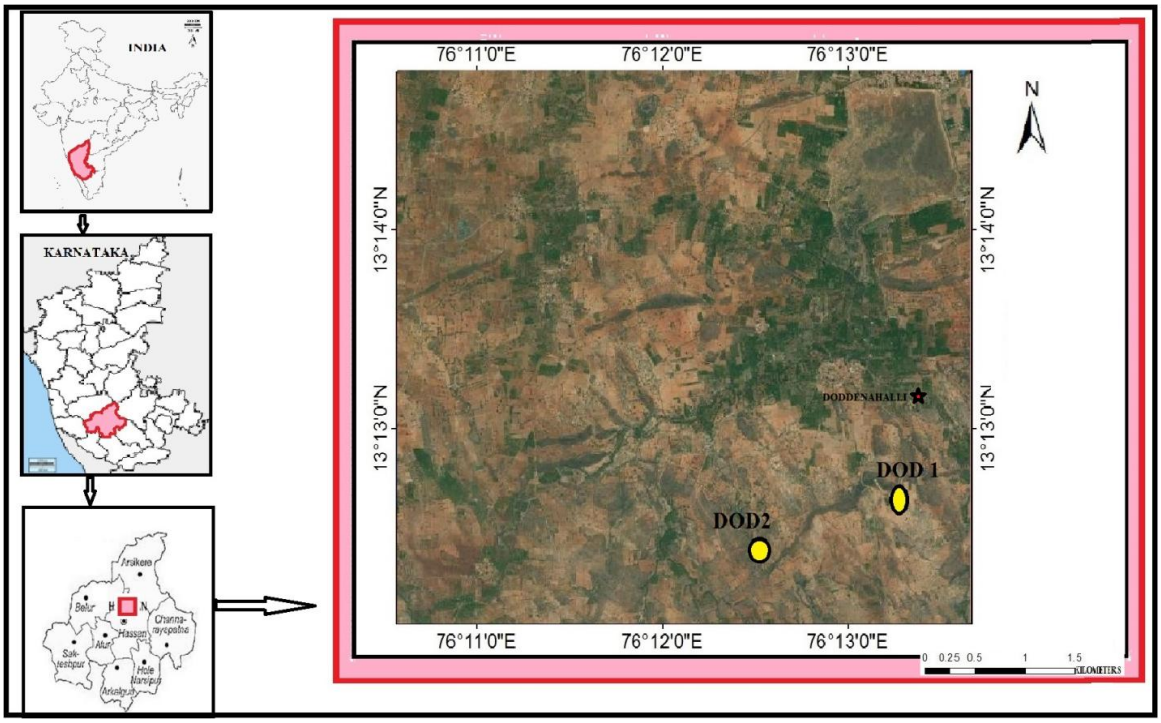

Fig.2. Google Earth Image showing the sample location of the Doddenahalli area

Table.1. Sample Name and Location

Sl No	Sample Name	Location	Latitude	Longitude
DOD1	STEATITE	DODDENAHALLI	13^0 12'42.22'' N	76^0 13'13.46'' E
DOD2	GNEISS	DODDENAHALLI	13^0 12'33.04'' N	76^0 12'27.06'' E

Note: DOD-Doddenahalli

PETROGRAPHY

Petrography is based on the study of the appearance of thin, transparent sections of rocks in a microscope. Many things can be studied with the help of optical microscope also the mineral phases (Basavarajappa et al., 2018).Much information of mineral content and the textural relationships within the rock can also be studied. Thin sections are great for identifying the minerals present, porosity, alteration, microstructures, and provenance.

STEATITE

It usually shows mg rich minerals like talc, olivine, serpentine, actinolite and pyroxenes thus making the rock sample light gray to blue gray in color. It shows massive in texture where majority of the minerals are altering into talc. Here talc mineral resulting from the metamorphism of ultramafic rock with magnesiam minerals such as serpentine, pyroxene, amphibole, olivine, in the presence of carbon dioxide and water. Talc is easily distinguishable by its extreme softness, color is white, colorless, pale to dark green, or yellowish to brown and shows moderate relief. It is often found mixed with other minerals, such as serpentine and olivine thus making denser. In plane polarized light it shows colorless and non pleochroic. With all the above observations seen the rock is identified as Steatite (Fig.3).

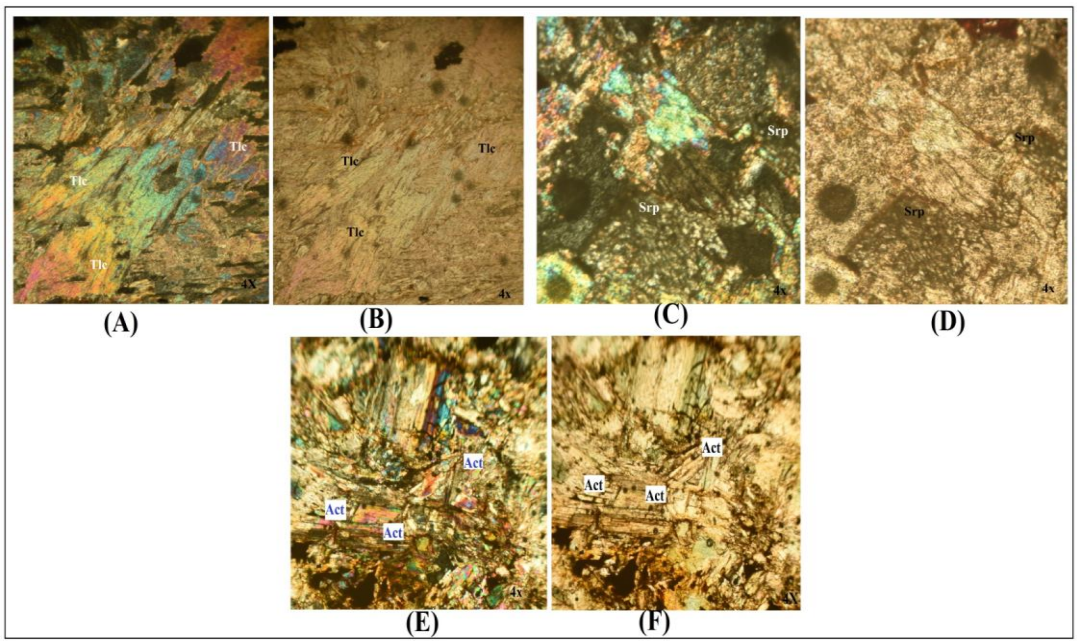

Fig.3. (A)(B) Photomicrographs of Steatite under PPL and XPL showing Talc .
(C)(D) Photomicrographs of Steatite under PPL and XPL showing Serpentine.
(E)(F) Photomicrographs of Steatite under PPL and XPL showing Actinolites

GNEISS

Gneiss sample shows banding of alternative light and dark color minerals with different chemical composition showing banded texture. Light color minerals include quartz and feldspar. Dark color mineral includes biotite mica. Minerals shows medium to coarse grained. Quartz has low relief, low birefringence. Plagioclase feldspars are easy to identify they display first order grays and stripey twins. (Fig.4).

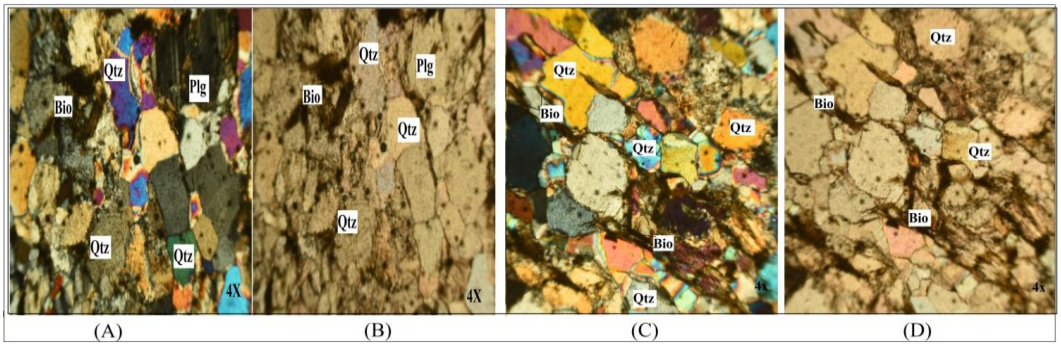

Fig.4.(A)(B) Photomicrographs of Gneiss under PPL and XPL showing biotite+quartz+plagioclase. (C)(D) Photomicrographs of Gneiss under PPL and XPL showing biotite and quartz

SEM-EDX

Scanning Electron Microscopy (SEM) magnifies a specific sample region and provides detailed high resolution images of the sample by rastering a focussed electron beam across the surface and detecting secondary or backscattered electron signal. 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. An Energy Dispersive X-Ray Analyzer (EDX or EDA) is also used to provide elemental identification of the mineral and quantitative compositional information of the mineral (Abrar Ahmed et al., 2019, 2020). SEM's can reveal micron scale surface features of a rock sample. This combined technique is referred as SEM-EDS or SEM-EDX analysis (PinakiSengupta et al., 2008).

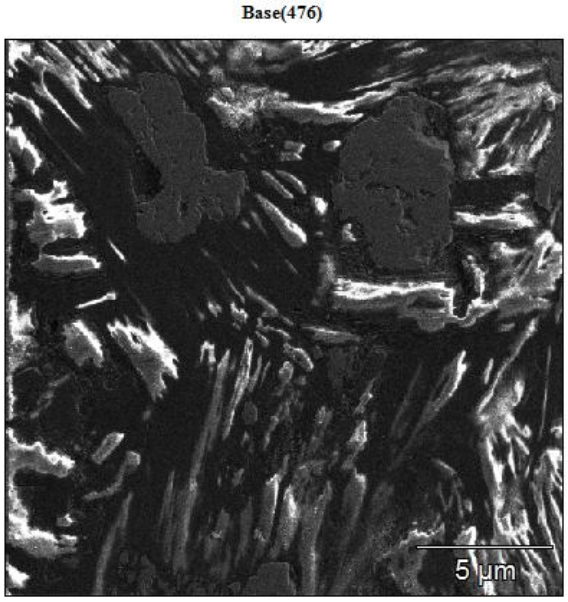

Fig.5. SEM image data of steatite

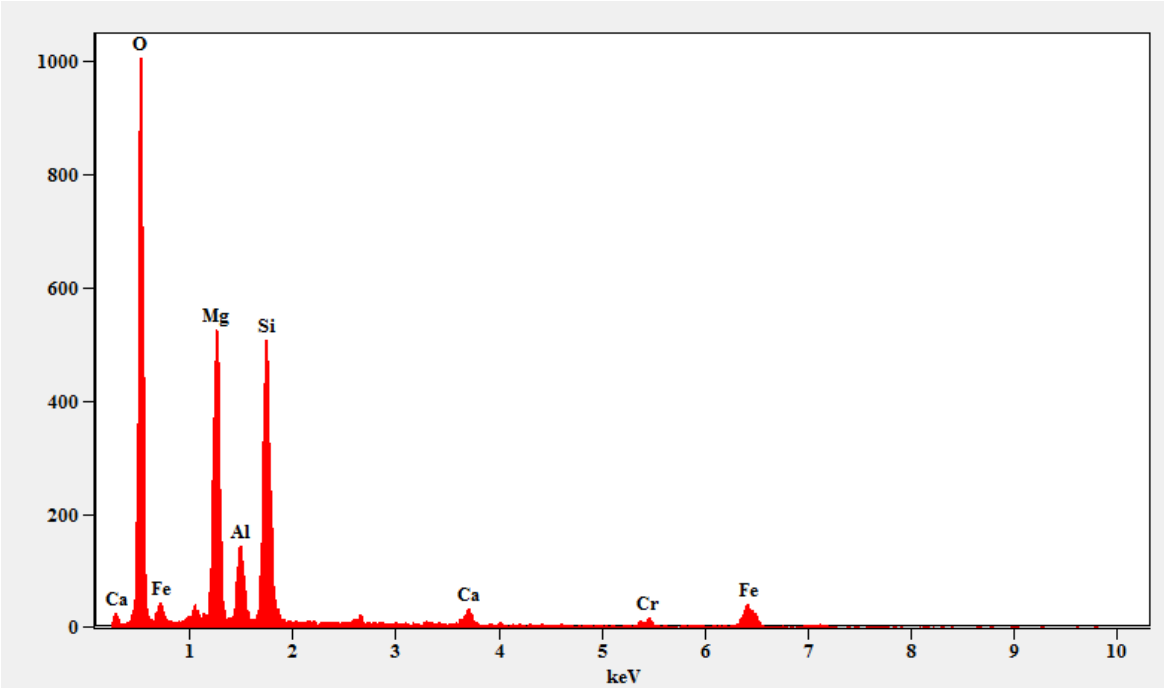

Fig.6. Typical EDX spectrum: y-axis depicts the number of counts and x-axis the energy of the X-rays. The position of the peaks leads to the identification of the elements and the peak height helps in the quantification of each element's concentration in the sample.

Table-2: Showing elemental analysis of Steatite

Element Line	Weight %	Weight % Error	Atom %
O K	54.18	± 0.75	68.59
Mg K	14.83	± 0.41	12.36
Al K	3.79	± 0.53	2.84
Si K	17.07	± 0.43	12.31
Si L	---	--	--
Ca K	1.29	± 0.22	0.65
Ca L	---	--	--
Cr K	1.37	± 0.18	0.53
Cr L	---	--	--
Fe K	7.48	± 0.69	2.71
Fe L	---	--	--
Total	100.00		100.00

Using EDX as an analysis method we can quickly generate information about the chemical composition of a sample including what elements are present as well as their distribution and concentration. The analyzed steatite rock contains the presence of elements like O, Mg, Al, Si, Ca, Cr and Fe were determined. Here mainly concentrate of Mg presence is about 15%.The elemental analysis photographs of individual elements of steatite rock is as shown below (Fig.7).

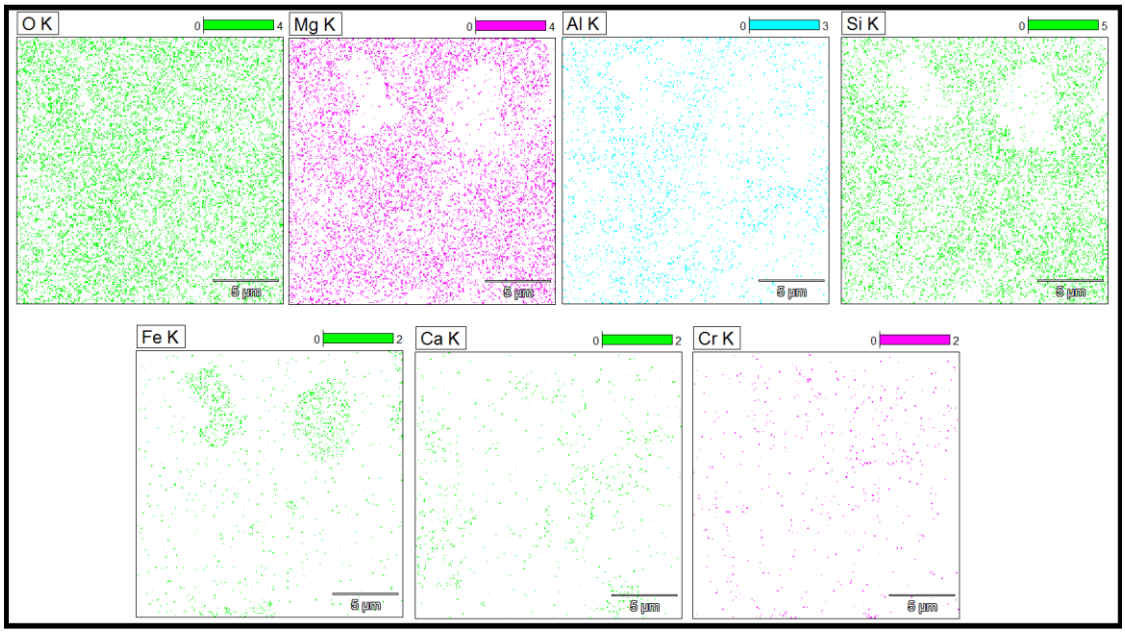

Fig. 7. EDX image analysis of individual elements of steatite

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)(Basavarajappa et al.,2020).

The given steatite rock shows spectral signatures of minerals like talc, actinolite, lizardite, mg-chlinochlore and serpentine.

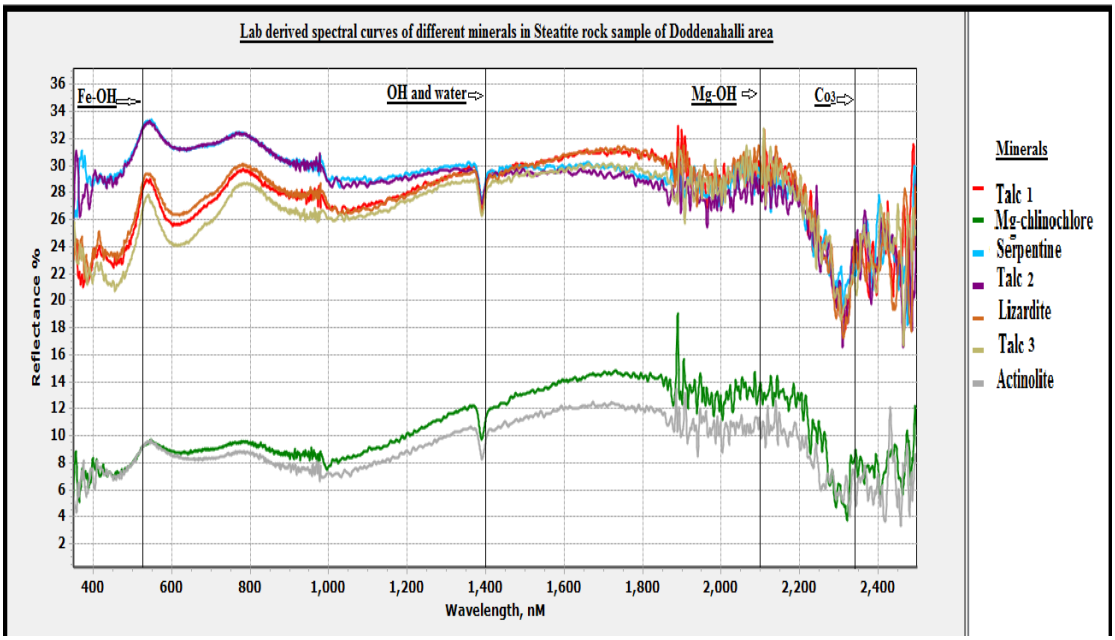

Fig.8. Lab derived Spectral curves of different minerals in steatite rock of Doddenahalli area

Table.3. Major Elements and Spectral analysis data of the samples of the study area

Chemical constituents		Talc		
		Talc1	Talc2	Talc3
Elements (wt%)	SiO2	58.38	58.50	58.00
	TiO2	0.03	0.03	0.03
	Al2O3	0.18	0.15	0.14
	FeO	0.22	0.30	0.30
	MnO	0.56	0.40	0.55
	MgO	31.90	32.50	32.00
	ZnO	0.03	0.028	0.03
	BaO	0.00	0.00	0.00
	CaO	0.65	0.65	0.60
	Na2O	0.17	0.10	0.10
	K2O	0.01	0.01	0.01
	Cl	0.01	0.01	0.01
	F	0.25	0.25	0.20
	Total	92.29	92.92	91.96

The lab spectra of majority of the minerals here shows reflection of Mg-0H band at 2300nm and absorb OH -Water at 1400 nm. In actinolite curve the weak band near 0.63nm indicates the presence of some ferric iron, which if often abundant in it. Usually large number of sharp reflections in actinolite indicating excellent crystallinity and suggesting compositional homogeneity. Lizardite (kaolinite-serpentine group), this is an isochemical end member of Mg-OH serpentine. Derived Minerals spectral curves were correlation with standard USGS spectral library. From all the spectral curves observed and studied in this sample they differ slightly. It suggests that the steatite has formed from the same parental magma with the alterations.

FieldPhotographs

Fig.9. Field photograph of steatite showing pitted appearance around Doddenahalli area.

Fig.10. Field photograph of steatite around Doddenahalli area.

Fig.11. Field photograph of Gneiss around Doddenahalli area.

III. CONCLUSION

Occurrences of steatite deposit around Doddenahalli village which is close to Bageshpura have been identified and demarcated. Steatite in the study area occurs as enclave in the banded gneiss trending in NNW-SSE to NW-SE direction.Petrography helped to know the minerals which are associated with steatite like serpentine, olivine and actinolite. SEM-EDX studies helped to know the high Mg elemental percentage present that is 15percent. Along with elemental mapping of elements like O, Mg, Al, Si, Ca, Cr and Fe present in the given steatite sample was known. Spectral signatures of minerals like talc, mg-chlinochlore, serpentine, lizardite and actinolite in steatite rock sample were derived and studied by Spectro-Radiometer instrument to know the purity of minerals which are present. The lab spectra of majority of the minerals here shows reflection of Mg-0H band at 2300nm and absorb OH -Water at 1400 nm. From all the spectral curves observed and studied it suggests that the steatite has formed from the same parental magma with the alterations. From the above studies carried out it suggests that steatite around Doddenahalli village is an important economic non-metallic mineral deposit.

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