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Creation of hyper spectral library and lithological discrimination of granite rocks using SVCHR -1024: lab based approach

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Abstract

The advances of worldwide research for identification of rocks and minerals in remote sensing data with a help of spectral pattern of different rocks and minerals now a days we all are referring only for USGS or JHU spectral library and these libraries were constructed mostly based on the lithological discrimination of rocks present outside of our country. There is no spectral library available for Rocks and Minerals present in Tamil Nadu. Hence the present study was under taken to construct the hyper spectral library using Spectroradiometer (SVC HR-1024) which covers 340nm to 2500nm wavelength and this study only carried out in the room environment. In the present study, for creation of the hyperspectral library 21 rocks of Igneous, Metamorphic and Sedimentary rocks were selected from the lab and spectral library was created using spectro radiometer. Different variety of granite rocks were selected based on their physical and chemical properties of rocks such as Granite (coarse and fine grain), Granodiorite, Granite porphyry, Graphic granite and Pegmatite rocks and their spectral reflectance were compare with both hyper spectral library which was created and universal spectral libraries. Spectral behaviour of selected granite rocks shows similar pattern of different rocks and minerals and some variations also observed because of different physical and chemical properties of minerals and environment of collection of spectral behaviour of rocks.

Keywords: Hyper spectral library, spectral reflectance, lithological discrimination, granite, SVCHR-1024.

1. Introduction

Hyperspectral remote sensing is the science of acquiring digital imagery of earth materials in many narrow contiguous spectral bands. Hyperspectral sensors or imaging spectrometers measure earth materials and produce complete spectral signatures with no wavelength omissions. Present study, analysis spectral reflectance of difference rocks and minerals in room environment using spectroradiometer (SVC HR-1024). The selected instrument was field portable spectroradiometer covering the UV, Visible, and NIR wavelengths from 350 nm to 2500 nm. It uses 3 diffraction grating spectrometers with 1 silicon and 2 InGaAs diode arrays. The silicon array has 512 discrete detectors and the InGaAs arrays each have 256 discrete detectors that provide the capability to read 1024 spectral bands (Figure 1). For handling this instrument in room environment, extra care also need to take care for room for avoiding noise for the spectral observation such as, the room should be very dark, there is no external light will enter into the room, Maintain a room temperature, should be 41deg Celsius, AC and fans should be avoid or switch off condition at the time of spectra collection. The instrument is mounted with a correct set up. Here two 100 watts Philips bulb was used for the better intensity (nearly 1 lakh 4 thousand).Fix the lens in the instrument, the focal angle of the lens is 4deg and the height between sample and lens is 10cm, then the FOV is 2.6x0.6cm.

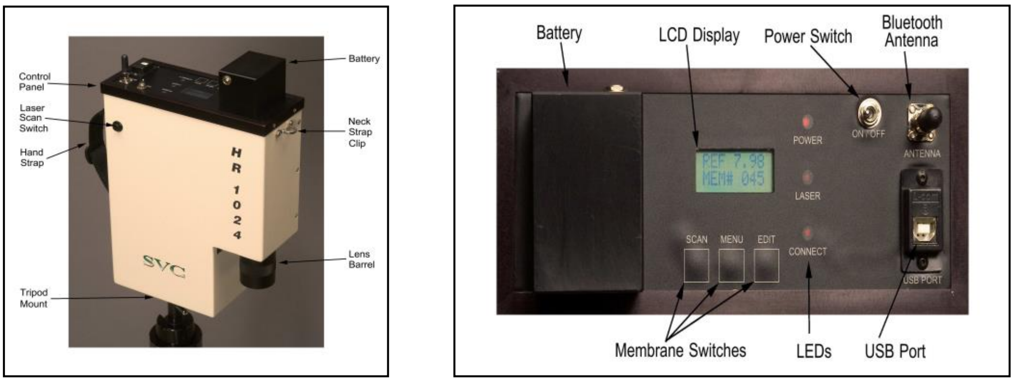

Figure 1 - Spectroradiometer (SVC HR- 1024).

2. Methodology

The methodology of the present study comprise of 3 major components that are

- Selection of different samples from lab
- Develop spectral library
- Validation of spectral pattern of selected Granite rocks

The flow chart (Figure 2) broadly explains the brief methodology followed in this study.

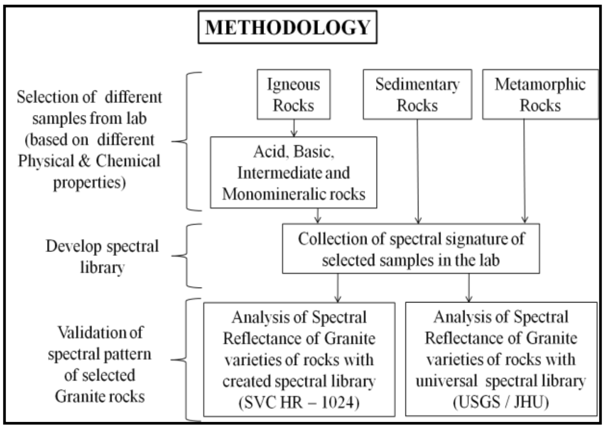

Figure 2 - Methodology.

3. Selection of samples from LAB

Out of number of rock samples, over 21 rocks were specifically identified for this experimental study (Figure 3). It was done in such a way that the rocks varying in physical and chemical composition.

IGNEOUS ROCKS

Acid Igneous rocks
- Granite
- Granodiorite
- Granite porphyry
- Graphic granite
- Pegmatite

Basic Igneous rocks
- Gabbro
- Norite

Intermediate Igneous rocks
- Diorite porphyry
- Dolerite porphyry
- Trachyte

Monomineralic Igneous rocks
- Anorthoscite
- Dunite
- Pyroxinite

METAMORPHIC ROCKS
- Augen gneiss
- Amphibolite
- Mica-schist
- Gneiss

SEDIMENTARY ROCKS
- Fossiliferous limestone
- Limestone
- Grit

Figure 3 - Samples selected for study.

4. Develop Spectral Library

Spectral pattern of selected 21 samples were collected using spectroradiometer (SVC HR- 1024), Barium plate (100% of Reflectance), Black color sheet (100% of absorption) and two tungsten lamp.

The main ethics involved in the method of data collection is the percentage of reflectance that is reflecting back from a sample, when light is falling on it. This is normally done by keeping a barium plate as standard object from which it is presumed that all the hundred percentage of the light incident upon it is reflected back. For reducing noise, all the samples were kept behind the black colour sheet during spectral survey because black colour sheets are having hundred percentage of the light were absorbed. Spectral reflectances of 21 rocks were collected in the lab environment (Figure 4A, B and C).

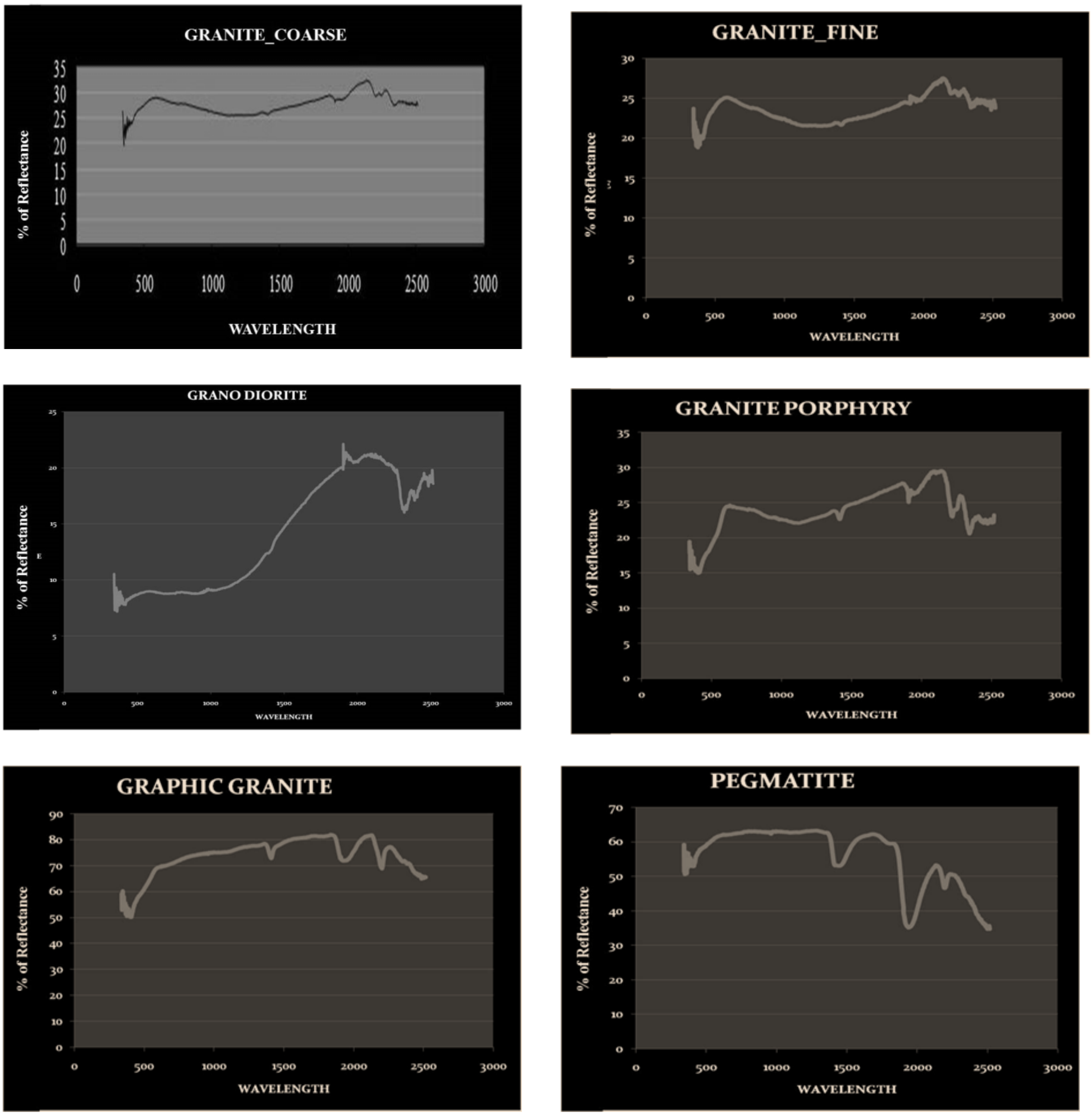

Figure 4A - Spectral reflectance of Igneous rocks (Acid, Basic, Intermediate and Monomineralic) (Continue…).

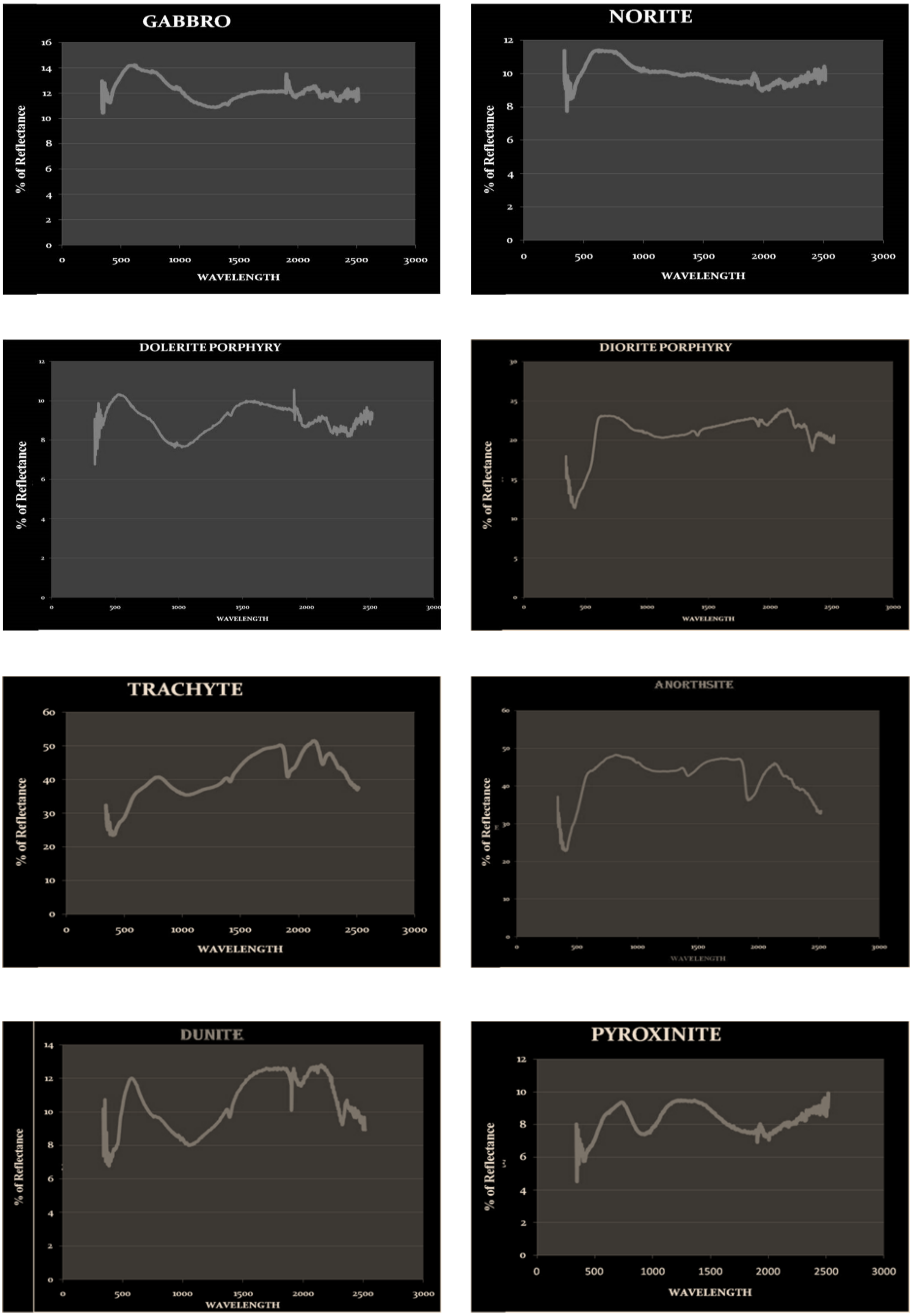

Figure 4A - Spectral reflectance of Igneous rocks (Acid, Basic, Intermediate and Monomineralic) (Concluded).

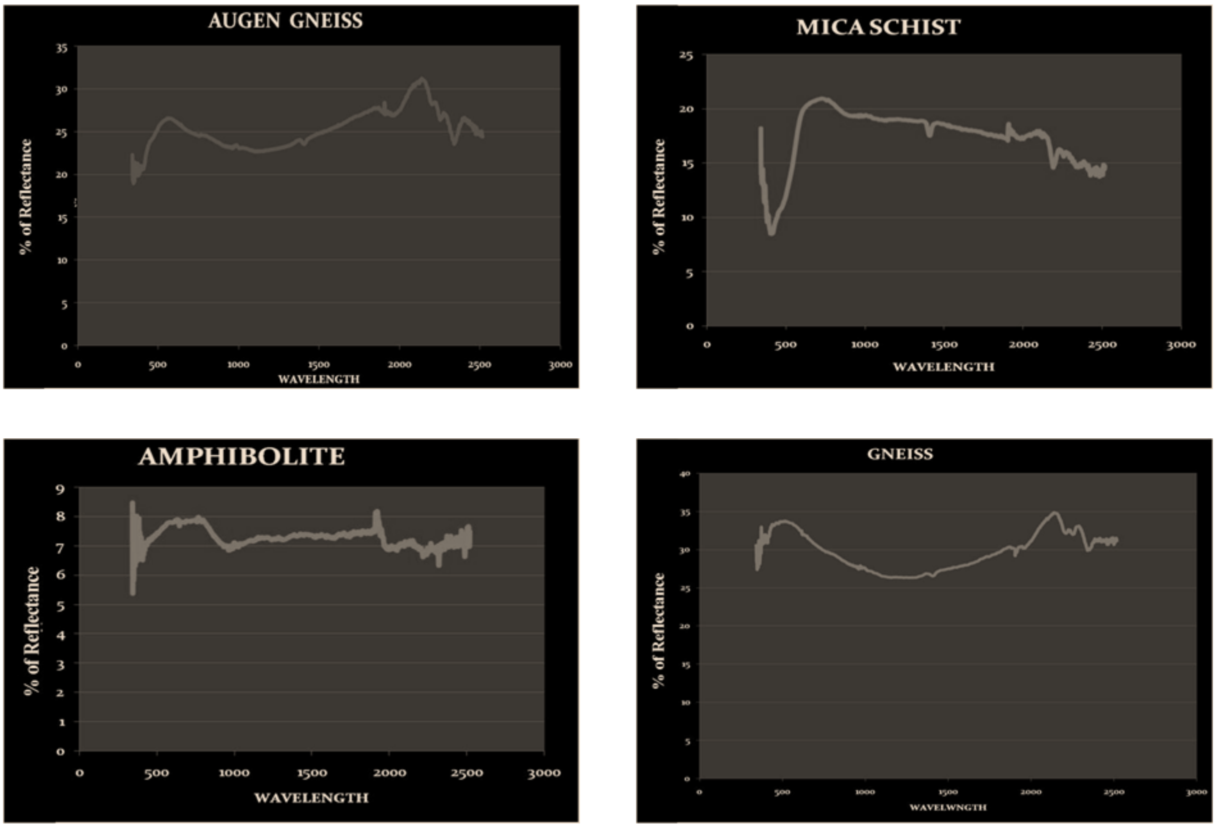

Figure 4 B - Spectral reflectance of Metamorphic rocks.

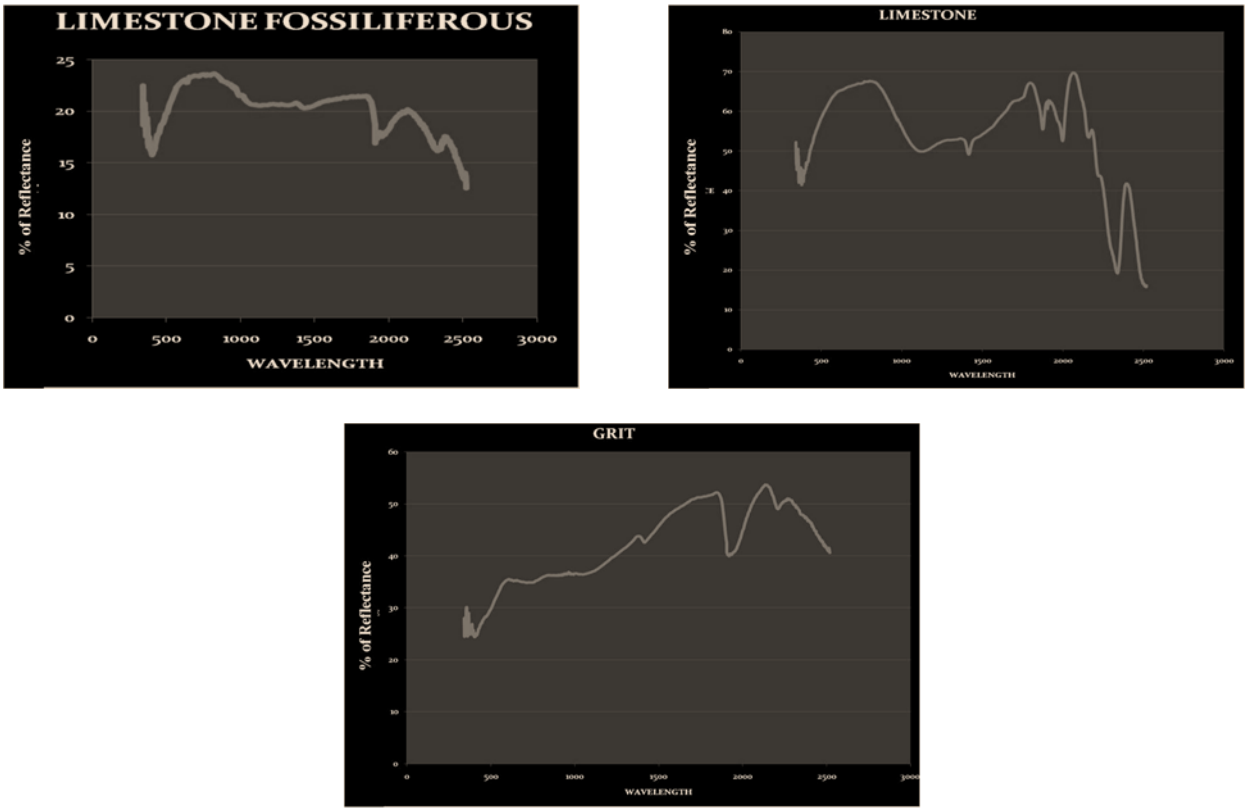

Figure 4C - Spectral reflectance of Sedimentary rocks.

5. Validation of spectral pattern of Granite rocks

Analysis of Spectral Reflectance of Granite varieties of rocks with created spectral library (SVC HR – 1024)

In general, physical properties of granites are Leucocratic in Colour, Medium sp.gravity, equigranular in texture and formed a natural associated characterized by the presence of quartz, orthoclase, plagioclase and various accessory minerals.

The general reflectance character of Quartz is shows high reflectance in Mid IR region (2.05x10-9) & the Maximum absorption in (2.43x10-9). Feldspar showing maximum reflectance in 2.3x10-9 & maximum absorption is at 0.4x 10-9 & mica showing high reflectance in 1.9x10-9 and maximum absorption is at 0.4x10-9. This general reflectance characterstics were also derived from the SVC HR-1024 instrument.

Granite is in different types based on the different chemical composition of minerals and physical properties like colour, texture. These changes are influence and shows different reflectance pattern.

The types of granites which are taken for analysis are

- Granite - Coarse grain
- Granite – Fine Grain
- Granite porphyry
- Graphic granite
- Pegmatite

Spectral characteristics of coarse grain Granite

Spectral curve for coarse granite shows high reflectance in 2.1μm with 27% of reflectance and maximum absorption is observed at 0.4μm.presence of magma influence maximum reflectance and quartz influences maximum absorption and high reflectance in visible region. Feldspar influences almost parallel smooth line in the infrared region. Figure 5A image of coarse granite and Figure 5B shows spectral curve for coarse granite.

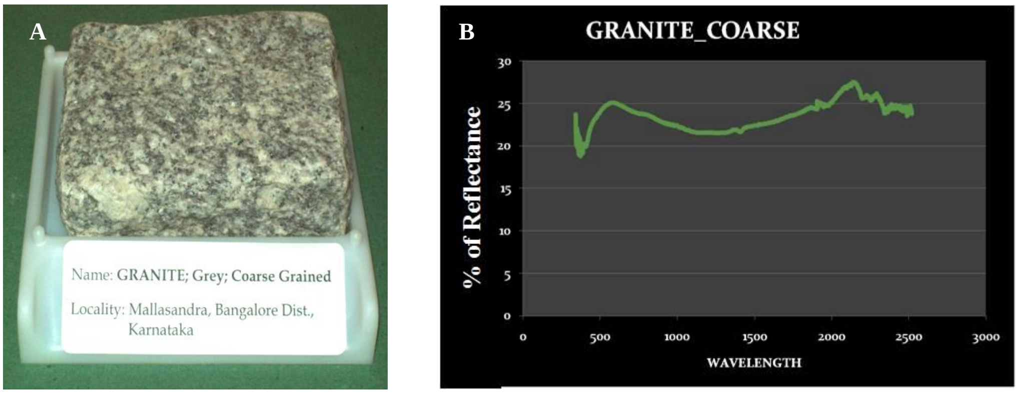

Figure 5 - Coarse granite (A) and spectral curve for coarse granite (B).

Spectral characteristics of fine Granite

Granite variety of fine grain also showing almost similar reflectance to compare to the granite coarse grain. it showing higher reflectance than coarse grain of granite in wavelength of 2.0 $x10^{-9}$.i.e, Coarse grain shows merely 27% of reflectance for the wavelength $2.09x10^{-9}$ whereas the fine grain shows quite higher percentage than that of the coarse grain .This may be due to the variation of the grain size their relative texture. Figure 6A image of fine granite and Figure 6B shows spectral curve for fine granite.

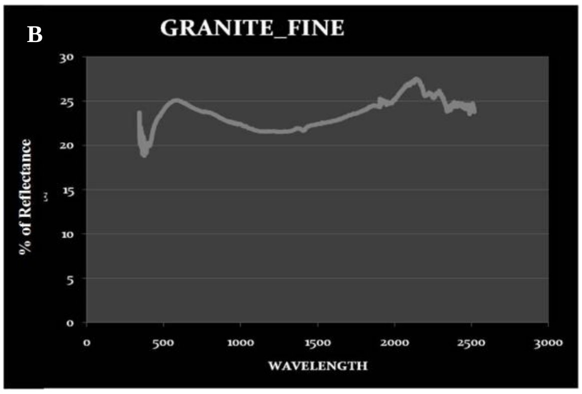

Figure 6 - Fine granite (A) and Spectral curve for fine granite (B).

Spectral characteristics of Granite porphyry

Another type of granite taken for the analysis is granite porphyry which has porphyritic texture with phenocrysts of light pink feldspar (Orthoclase). In general it too follows similar pattern of reflectance but in order it shows higher reflectance at $2x10^{-9}$ and shows maximum absorption at $0.5x10^{-9}$ as similar as the other granite variety but the percentage of absorption is quite 5% higher than that of the others. Figure 7 shows spectral curve for granite porphyry.

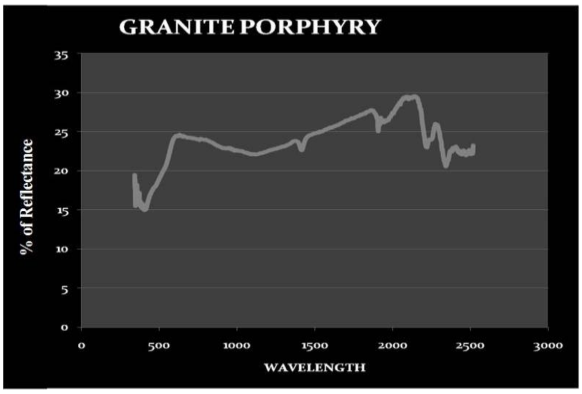

Figure 7 - Spectral curve for Granite porphyry.

Spectral characteristics of Granodiorite

Granodiorite have quartz and orthoclase in lesser percent than the granites also the percent of Plagioclase gets higher from Granodiorite to diorite. As we know that the Plagioclase minerals are highly enriched with Labradorite mineral which shows Zebra cross twining.

Due to the presence of Plagioclase in higher percent and less percent of quartz the reflectance curve attained for this Granodiorite gets deflected from the normal Pattern of Granite signatures i.e., shows maximum absorption percent at $0.4x10^{-9}$ of wavelength and shows a linear pattern of higher absorption up to $0.5x10^{-9}$ of wavelength. From this point of wavelength the Granodiorite shows a gradual increase of reflectance curve from $0.5x10^{-9}$ upto $2.0x10^{-9}$ of wavelength and though it shows higher reflectance at $2.0x10^{-9}$ of wavelength the percent of reflectance is much lesser than the Granite this may be due to the lesser amount of quartz content and the enriched content of Plagioclase minerals. Figure 8 shows spectral curve for granodiorite.

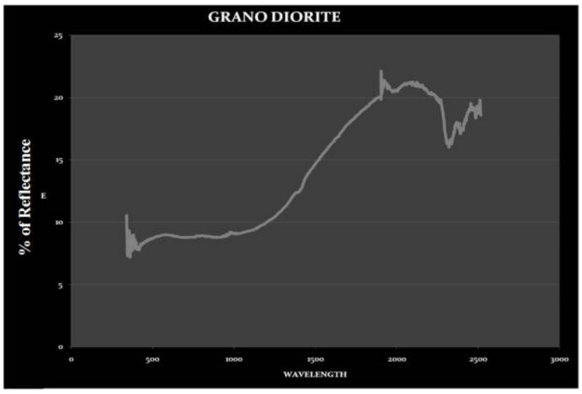

Figure 8 - Spectral curve for Granodiorite

Spectral characteristics of Graphic granite

This is also a variety of granite which is enriched in plagioclase and shows similar pattern of reflectance in lower wavelength of $0.3x10^{-9}$ to $0.5x10^{-9}$ and in the higher wavelength of $2.0x10^{-9}$to $2.3x10^{-9}$. As like the Granodiorite this is also has higher percent of plagioclase minerals the wave pattern is not much similar to granite except in the lower level of wavelength i.e., $0.34x10^{-9}$ and the higher wavelength i.e., >$2.0x10^{-9}$.the pattern of reflectance is like a gradual increase from $0.5x10^{-9}$ wavelength and forms entirely different pattern of spectral curve than the Granite and Granodiorite. Also the higher reflectance level at $2.0x10^{-9}$ is merely 30% lesser than the Igneous Granite. Figure 9A image of Graphic granite and Figure 9B shows spectral curve for Graphic granite.

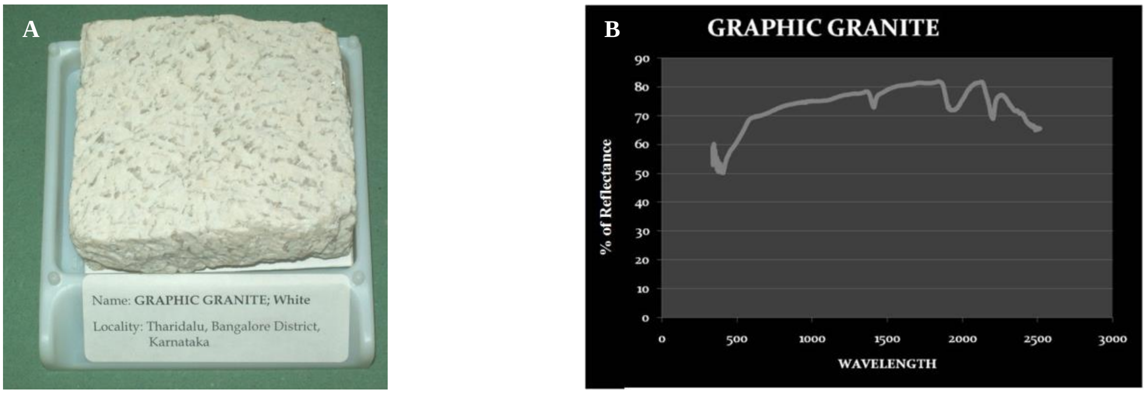

Figure 9 - Graphic granite (A) and spectral curve for Graphic granite (B).

Spectral characteristics of Pegmatite

AS similar to the granite's mineralogical composition Pegmatite too consist of Quartz, Feldspar & mica. But in order the Feldspar content in Pegmatite are Plagioclase minerals and Muscovite for mica content, As Discussed earlier the presence of Plagioclase shows a major conflict pattern of spectral signature when compared to Granite.

In Pegmatite the reflectance percent maintains a mere straight line from 0.5x10-9 to 1.4x10-9 this is much similar to Graphic Granite which shows a Gradual increase from 0.3x10-9 to 2.0x10-9 wavelength. Figure 10A image of Pegmatite and Figure 10B shows spectral curve for Pegmatite.

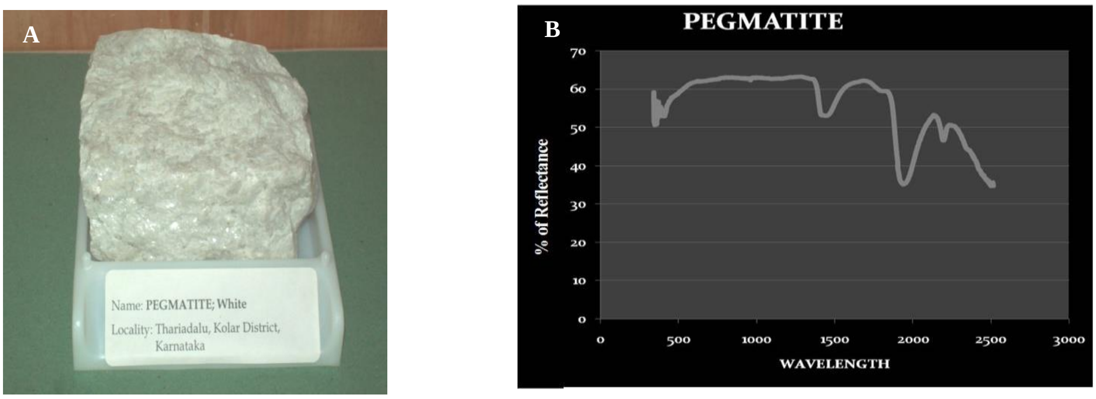

Figure 10A – Pegmatite (A) and spectral curve for Pegmatite (B).

Analysis of Spectral Reflectance of Granite varieties of rocks with universal spectral library (USGS / JHU)

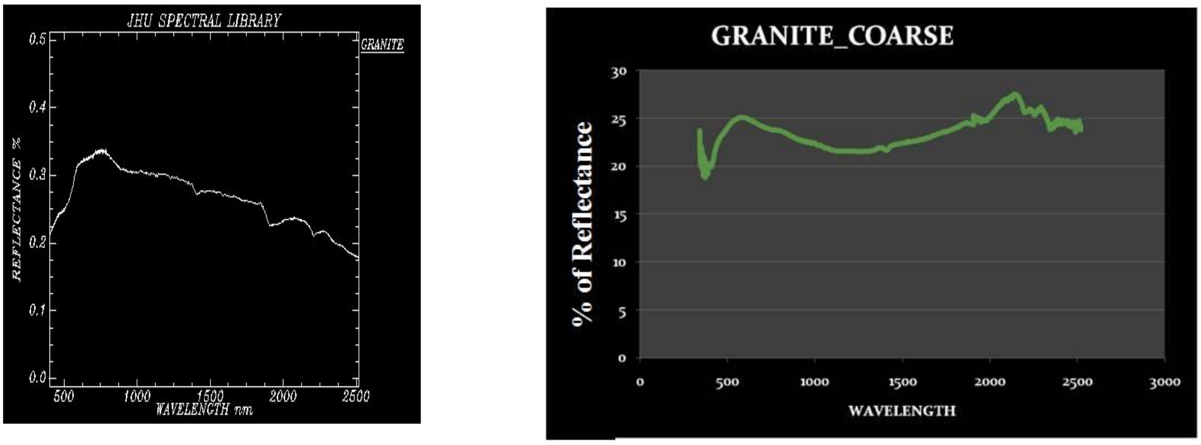

Figure 11 - JHU Library (A) and spectral curve for Granite (B). SVC HR – 1024 Library

6. Conclusions

Reflectance Spectroscopy is a rapidly growing science that can be used to derive significant information about mineralogy .it may use in application when other methods would be too time-consuming or require destruction of precious samples. For example, imaging spectrometers are already acquiring millions of spectra over an area from which mineralogical map being made. Spectral databases are now becoming available (Clerk et al., 1993) An advantage of spectrometric investigations is much information including in obtained results. This allowed their users decode indication for type classification of studied objects.

A detailed framework for this study of spectral emissivity measurements using a field-portable SVC 1024 spectrometer. The methodology and setup were evaluated by measuring a sample of known composition (Granite), revealing that errors from radiometric calibration and system performance have a comparable impact as those linked to the approach taken to separate the temperature and emissivity signature of the target.

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