EXPLORATORY PROJECT

MINERAL CLASSIFICATION USING HYPERSPECTRAL IMAGING

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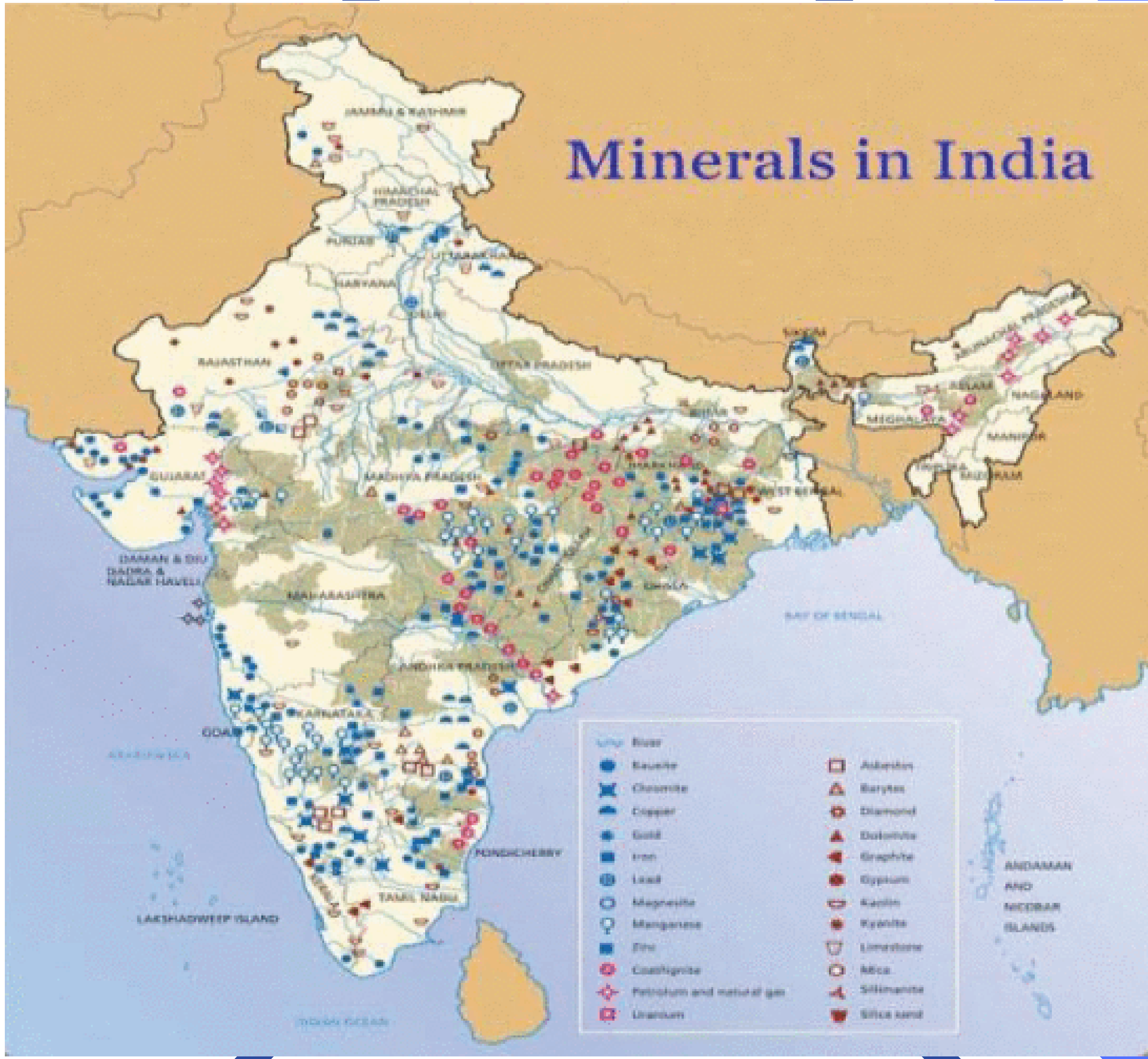
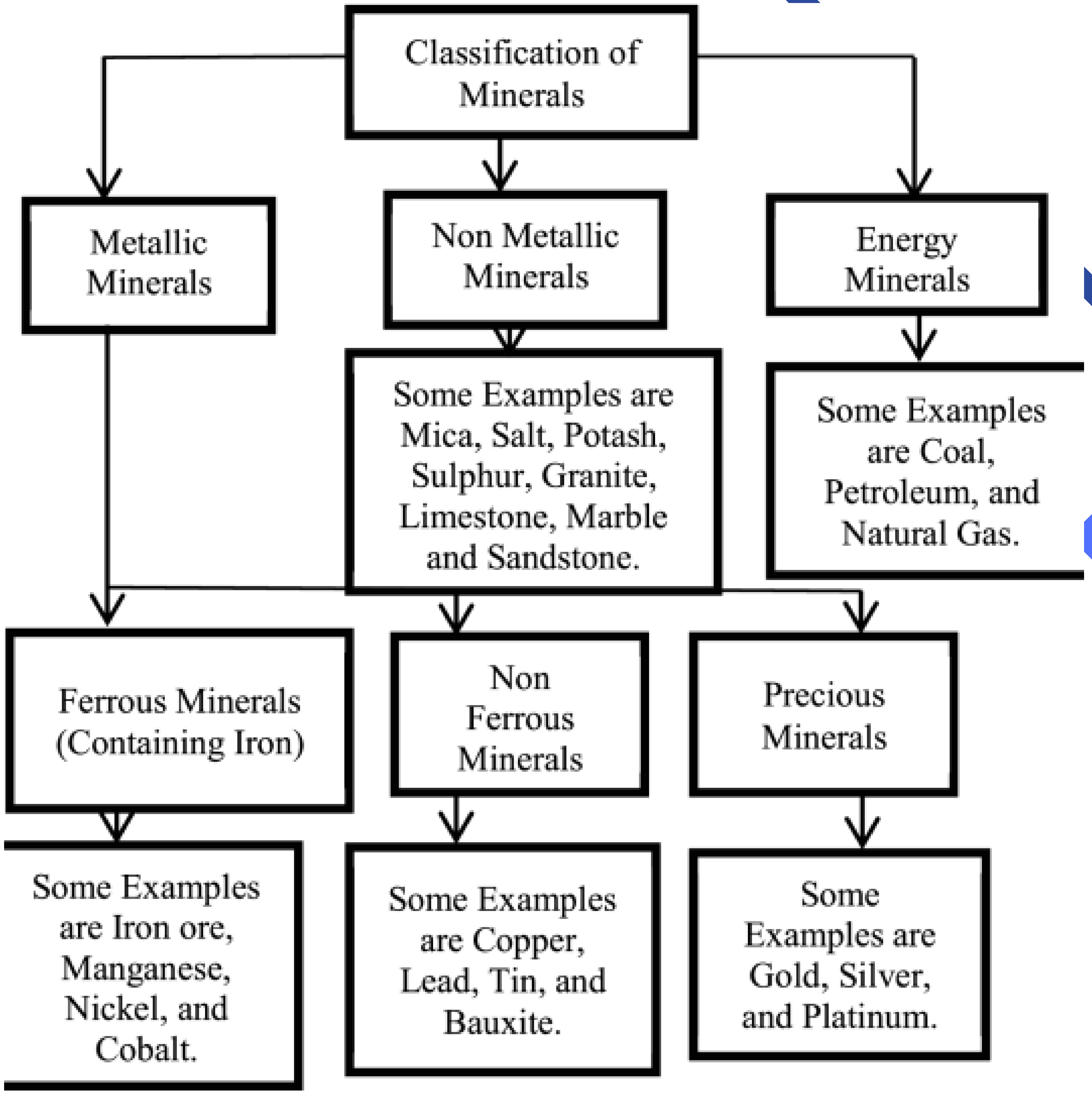
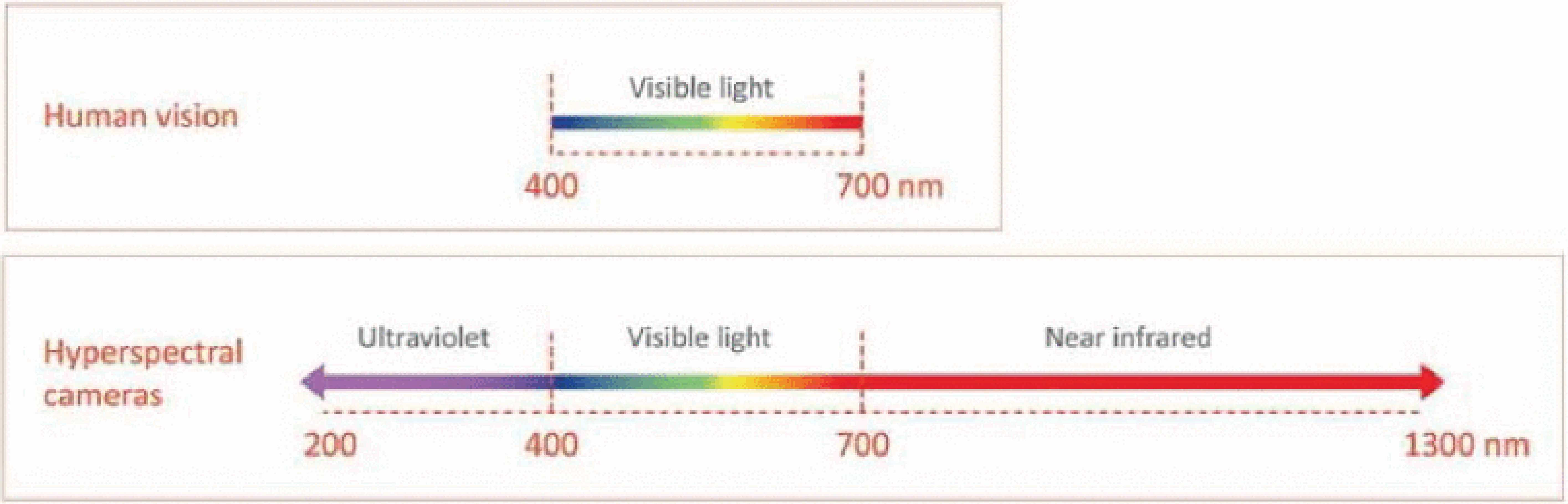
India is a mineral rich country and ranks fourth amongst the mineral potential countries. However, the full mineral potential is yet to be explored and assessed, leading to good opportunities for mineral exploration development.

Remote sensing technique was developed in 1880. It has been used in multispectral and uses Hyperspectral scanners, images to construct a complete reflectance spectrum of each pixel in the image. It is used for geological mapping and mineral exploration from 1970.

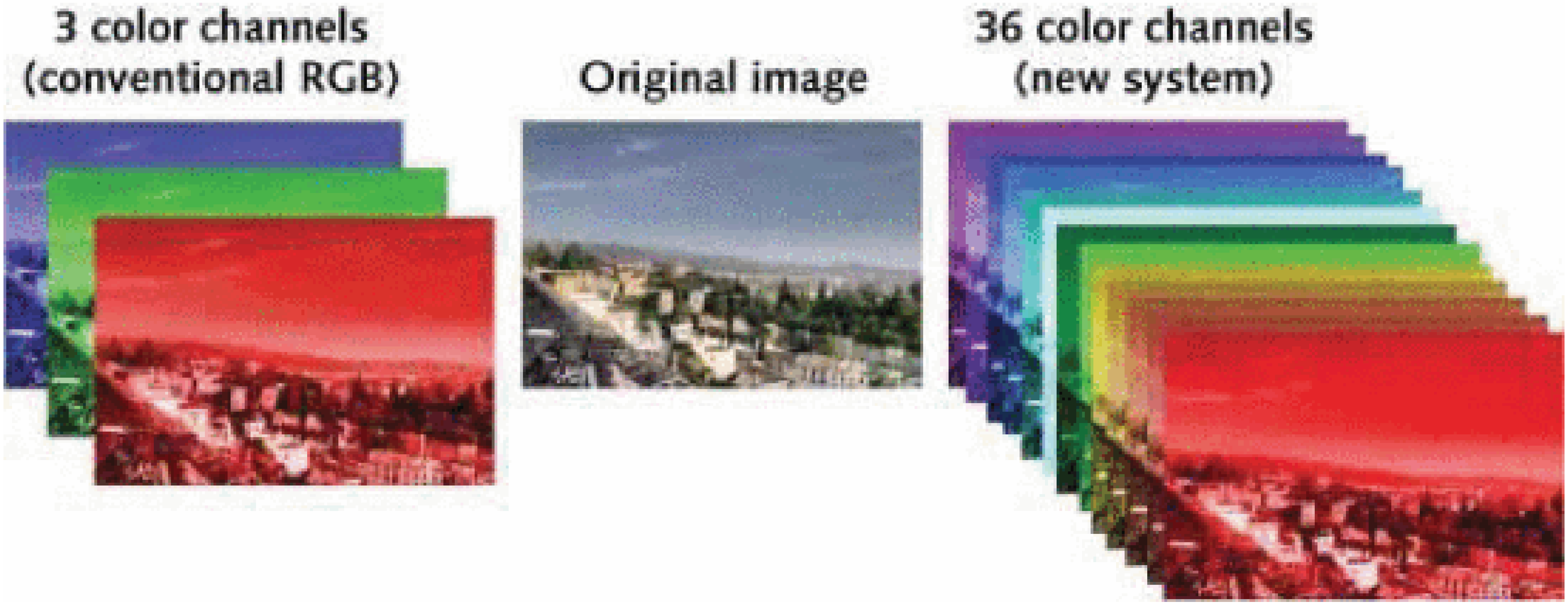



Classification of Minerals
Metallic Minerals
Non Metallic Minerals
Energy Minerals
Some Examples are Mica, Salt, Potash, Sulphur, Granite, Limestone, Marble and Sandstone.
Some Examples are Coal, Petroleum, and Natural Gas.
Ferrous Minerals (Containing Iron)
Non Ferrous Minerals
Precious Minerals
Some Examples are Iron ore, Manganese, Nickel, and Cobalt.
Some Examples are Copper, Lead, Tin, and Bauxite.
Some Examples are Gold, Silver, and Platinum.

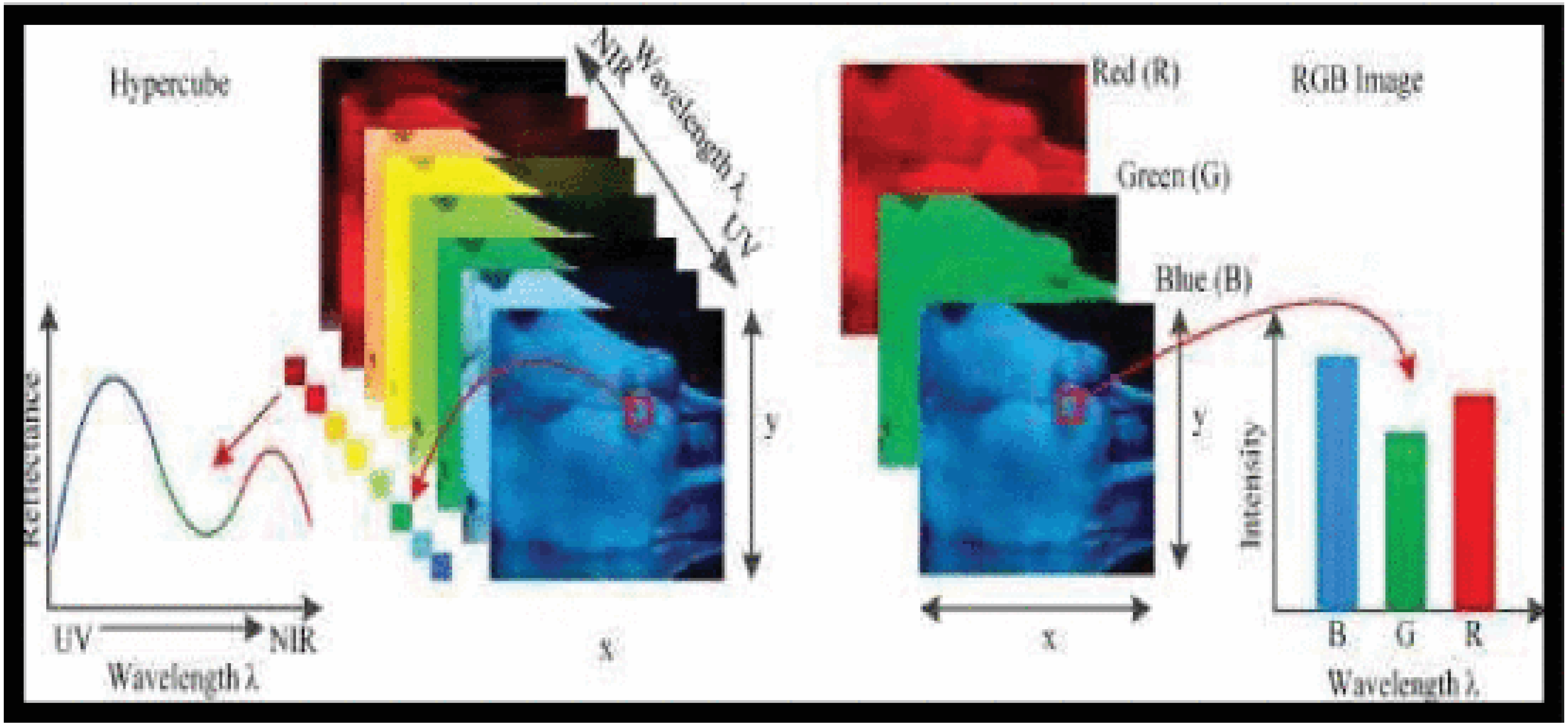
A TYPICAL HUMAN EYE IS ABLE TO VIEW A LIMITED RANGE OF ELECTRO-MAGNETIC SPECTRUM (390-700NM). ELECTROMAGNETIC RADIATION IN THIS RANGE OF WAVELENGTHS IS CALLED VISIBLE LIGHT OR VISIBLE SPECTRUM. HUMAN CAN DISTINGUISH BETWEEN OBJECTS BASED ON THEIR DIFFERENT SPECTRAL RESPONSES IN THAT NARROW SPECTRAL RANGE. FIG. 3. SHOWS RANGE OF OPERATION OF NORMAL AND HYPERSPECTRAL CAMERAS. HOWEVER, THE HYPERSPECTRAL IMAGING SENSORS AND MULTISPECTRAL IMAGING SENSORS HAVE BEEN DEVELOPED TO ACQUIRE AN IMAGE IN INFRARED AND VISIBLE SEGMENTS OF ELECTROMAGNETIC SPECTRUM. FIG INDICATES THE MULTISPECTRAL, NORMAL AND HYPERSPECTRAL IMAGE FOR A SPECIFIC PLACE.



Range of operation of normal and hyperspectral cameras.



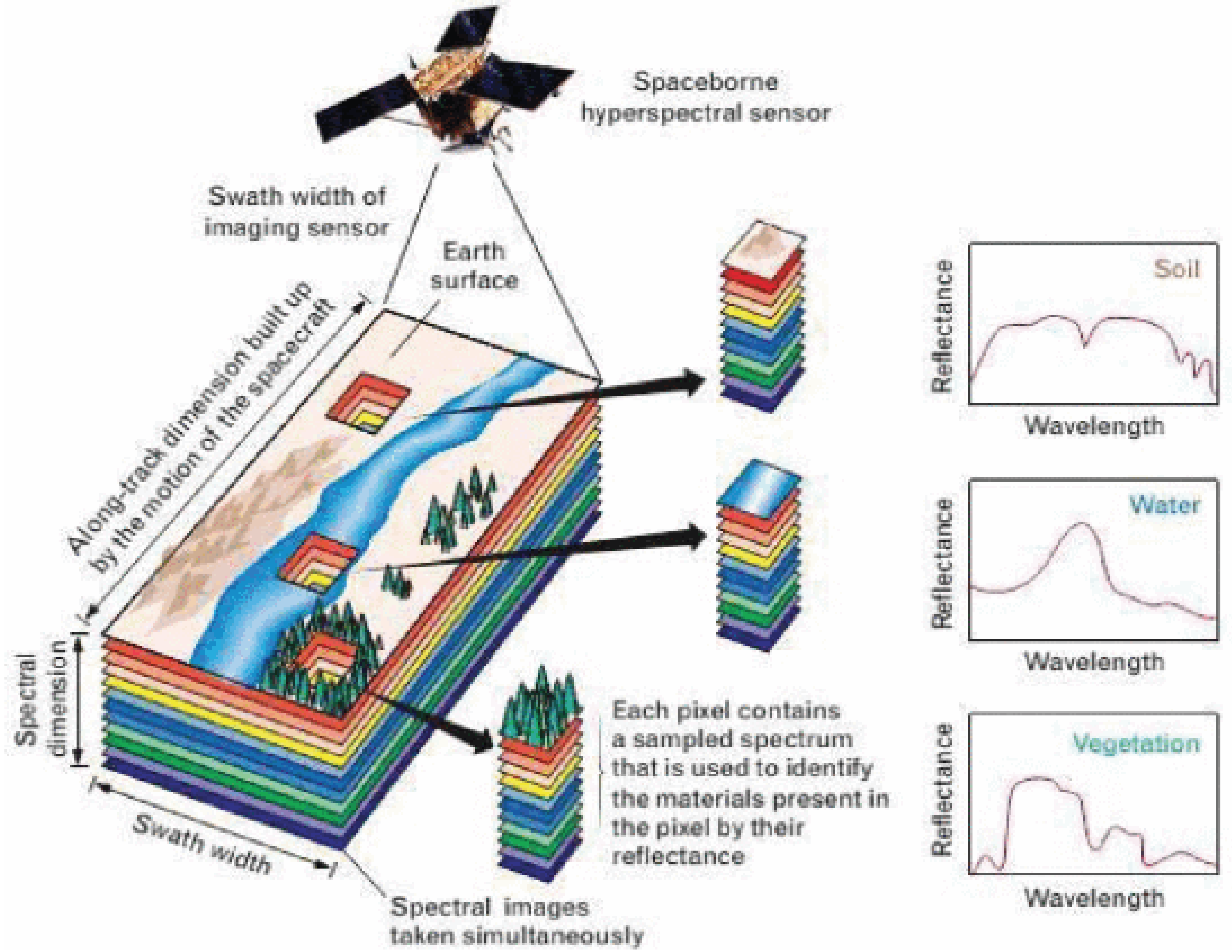
Multispectral, normal and hyperspectral image for a specific place.



Shows the plot between the Wavelength vs. Intensity for the hyperspectral and multispectral data.

Hyperspectral Imaging

The purpose of the hyperspectral imaging is to identify the material required and to obtain the spectral of each pixel in the image. The Hyperspectral image is obtained from the solar radiation that is scattered from the Earth’s surface, which after interaction with the atmosphere reaches the sensor. The Hyperspectral image is obtained from EO-I (Earth Orbiting) satellite. Hyperion provides high resolution hyper spectral images capable of resolving 220 spectral bands and resolution of 30m. The Instrument covers an area up to 7.5km by 100km land per image. This provides a precise spectral mapping over 220 channels with very high radiometric accuracy.

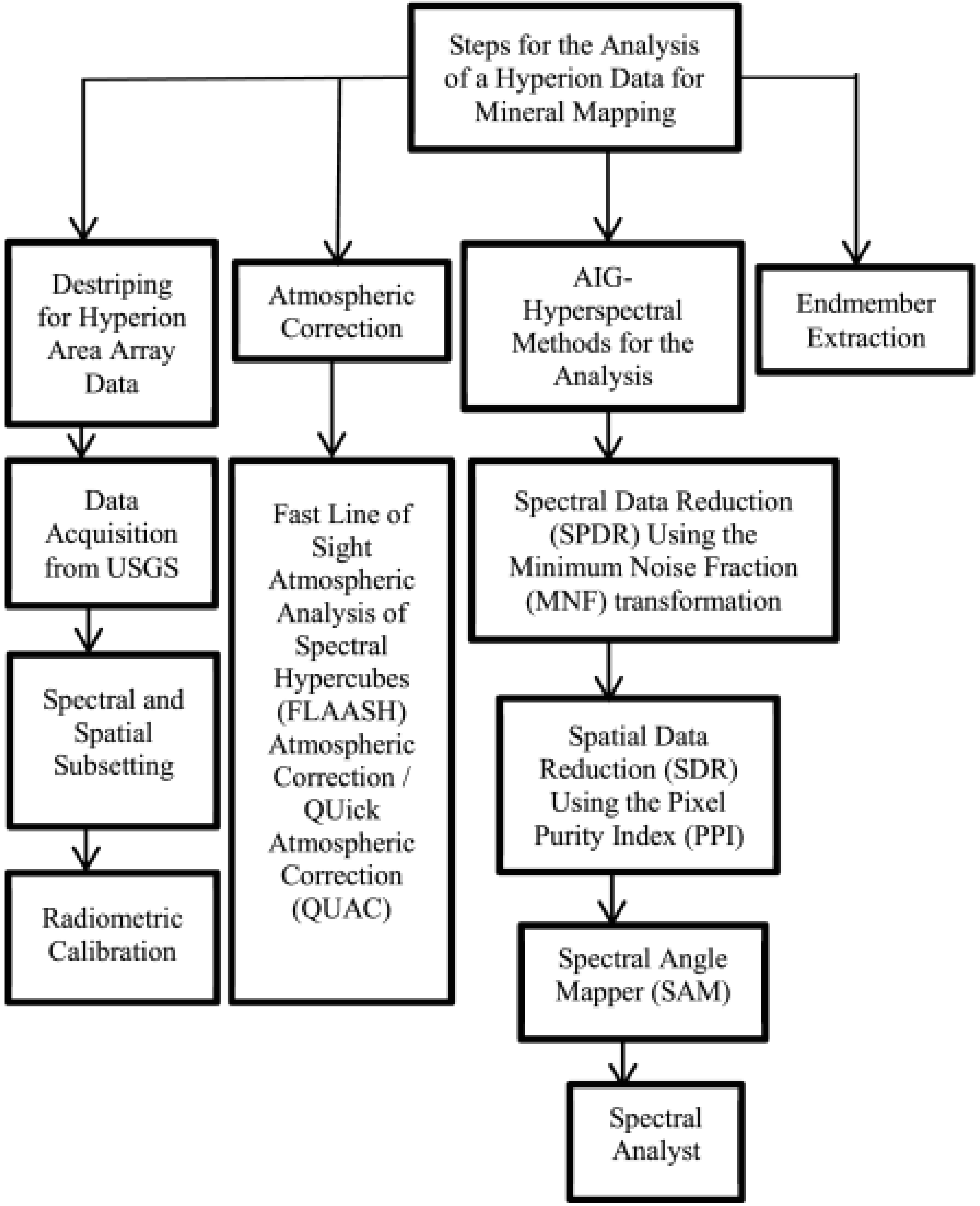


Mapping of soil, water & vegetation using HSI technique

Hyperspectral Techniques For Mineral Mapping

Interpretation of Hyperspectral data has been developed by Analytical Imaging and Geophysics (AIG). These approaches are implemented in the “Environmental for visualizing Images”. AIG scientists developed ENVI system software. The Hyperspectral anatomization methodology includes

1. Data pre-processing
2. Atmospheric correction is necessary for finding the apparent reflectance of the data
3. Linear transformation of the reflectance data to reduce noise and determine data dimensionality
4. Location of the most spectrally pure pixels
5. Extraction and automated identification of end member spectra
6. Spatial mapping and abundance estimates for specific image end members.



-Steps for the analysis of hyperion data for mineral mapping.

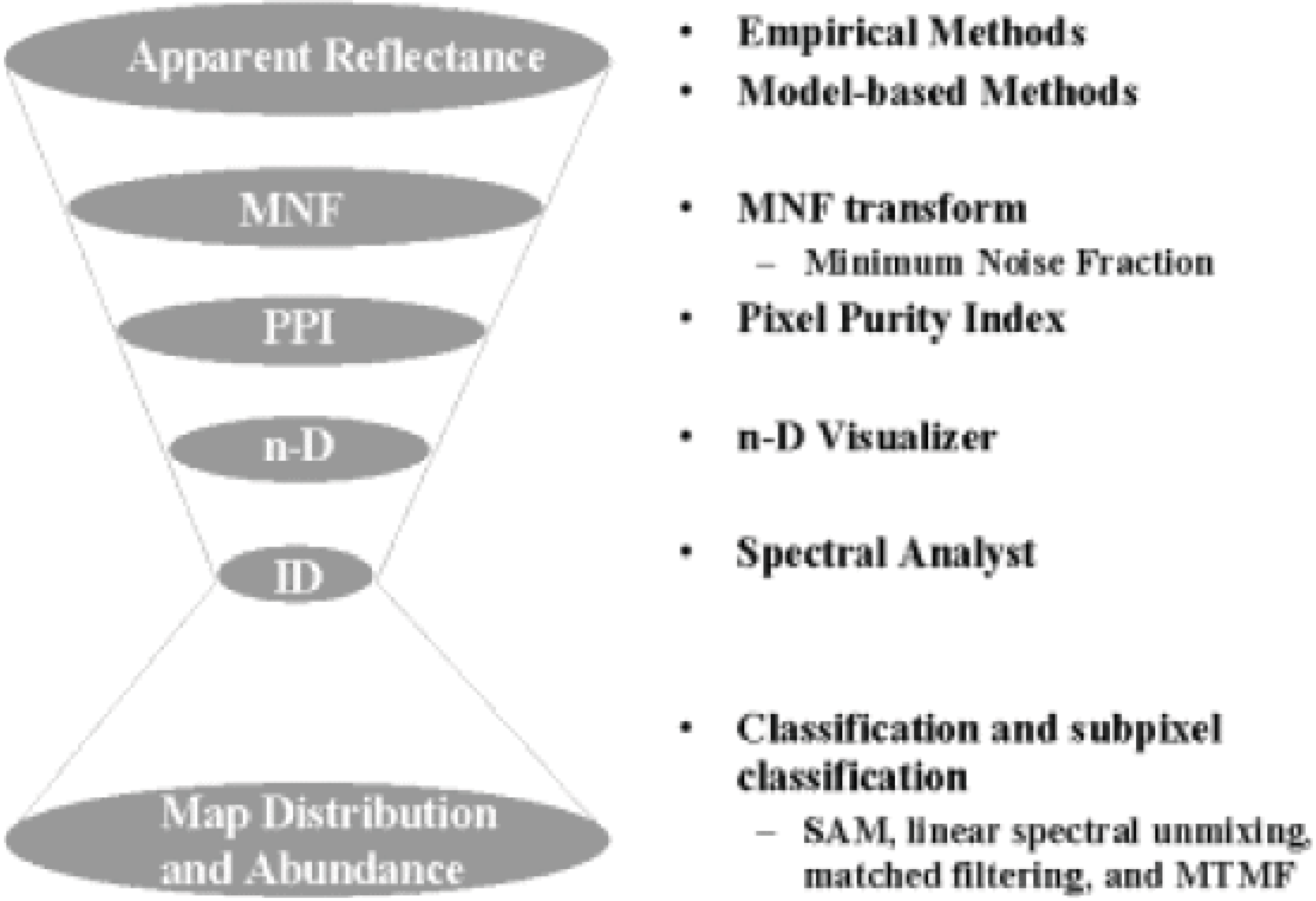
The following are the steps to be performed for the analysis of a Hyperion data.

A. Destriping for Hyperion Area Array Data

It is necessary that preprocessing must be applied to the data prior to atmospheric correction. There was still a striking vertical striping pattern in the data, though radiometric corrections were implemented on the Hyperion data. Aspects such as detector non-linearities, movement of the slit and temperature effect may be caused by AIS. Destriping is necessary only for correcting the Pushbroom Hyperion data. The destriping of a hyperion data has the following procedures they are given below.

1) Spectral and Spatial Subsetting:
Eliminating some portions for foreshortening the size of the data which are contemplated useless is called sub setting a dataset or the information is just comparatively less or not present. Spectral subsetting is used to restrain the number of bands in the input images. Bad bands are done based on eradicating or deselecting certain bands from input data. Spatial subsetting is done by selecting a small region in the input image of our interest for analysis.

2) Radiometric Calibration:
Radiometric errors will entail any form of image. The sensors absorb emitted and reflected waves. The error due to atmospheric condition causes absorbed wave may or may not coexist with the emitted wave, this result in improper irradiance values and radiometric correction is mandatory. It calculates the radiance, reflectance and brightness of the data subset.



AIG Hyperspectral Methods for Analysis

B. Atmospheric Correction

This analysis can be used for both Airborne & Satellite data. However, this method includes processing radiance calibrated data to apparent reflectance. Airborne and satellite Hyper spectral data is corrected and converted to apparent reflectance by using the Atmospheric CORrection Now (ACORN). Appropriate model parameters used for each instrument are sensor altitude, date, time, seasonal atmospheric model, latitude/longitude and average elevation. The different methods of atmospheric corrections are given below.

1) FLAASH- Fast Line of Sight Atmospheric Analysis of Spectral Hypercubes:
Nisha Rani et al. FLAASH is a model approach that is based generally on radiative transfer model. It is rigorous atmospheric algorithm and involves various parameters to perform but it has ability to compensate the effects of atmospheric absorption. FLAASH provides smooth spectral curves which helps in accurate identification of composition of minerals.

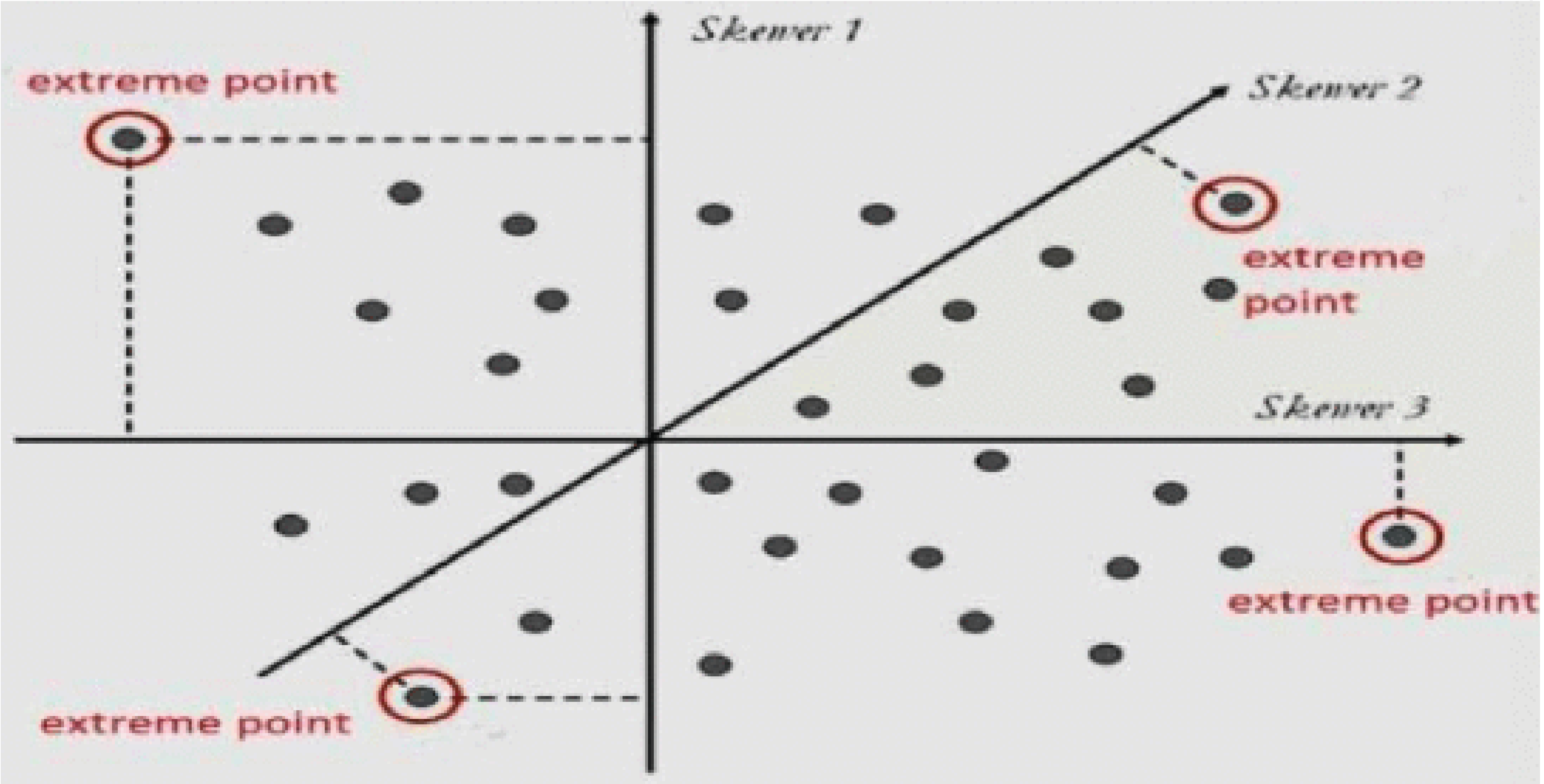
2) QUAC- QUick Atmospheric Corrections:
Nisha Rani et al. QUAC is an empirical approach that is scene-based and determines atmospheric compensation parameters directly from the information contained within the scene without ancillary information. It uses the information within the scene. Radiometric calibration is not required for this method.

C. AIG- Hyperspectral Methods for the Analysis

Hyperion data are processed based on the following methods for the analysis given below. Fig. 12. Shows the AIG Hyperspectral Methods for Analysis.

1. Spectral Data Reduction Using the Minimum Noise Fraction (MNF) transformation.
2. Spatial Data Reduction Using the Pixel Purity Index (PPI).
3. Spectral Angle Mapper (SAM).
4. Identification of endmembers using their reflectance spectra in the Spectral Analyst.

1) Spectral Data Reduction Using the Minimum Noise Fraction (MNF) Transformation:
To determine the image dimension Hyperspectral imaging data is used on Minimum Noise Fraction (MNF). MNF will separate the noise from signal and it is followed by inverse transform to produce spectral images which is completely noise free. MNF transformation shows that the vast majority of unique spectral information will be contained within the first few bands of the data.



SDR using pixel purity index

2) Spatial Data Reduction Using the Pixel Purity Index (PPI):
Spectrally pure pixels out of the given hyperspectral images is the designate of PPI. To perform dimensionality reduction either PCA/MNF transform is indispensable by PPI algorithm. PCA or MNF are second order, statistics need not to be desiccate for higher order. They produce large number of random vectors. Figure shows the purest pixels in different skews. A pixel is identified by an extreme of all the projections when it is presented by ultimate score. Spectrally high score and pure images are darker pixels over the output of the spectral image will be the brighter one.

3) Spectral Angle Mapper (SAM):

Matching of the spectral library to each of the image spectra is called spectral angle mapping. If identifies the parallelism between two spectra and is done by calculating the spectral angle between them. The vector in space is the spectral angle for the reference spectra no of classes or spectral library is taken from the SAM algorithm. SAM is used for calculating the angular distance between each of the image spectra and the reference spectra . Graphical output is given by the SAM, darker pixels are represented by smaller spectral angles. Smaller spectral angles indicate greater similarity between the reference and the input spectrum. Ines Dumke et al. provide the spectral classification difference between SVM and SAM. SAM method was able to distinguish these non-sediment pixels from the background sediment, it was often not able to classify them in the same way as SVM. SAM provides better accuracy for mineral mapping than SVM. BI Xiaojia et al. SAM provides enhanced reflectance curve for carbonate altered minerals like calcite, dolomite, siderite and gypsum. T. J Cudahy et al. proposed Mixture Tuned Marched Filtering (MTMF) algorithm instead of SAM. MTMF has an advantage of excellent spatial coherency and correlates well with the published geology.

4) Identification of Endmembers Using their Reflectance Spectra in the Spectral Analyst:

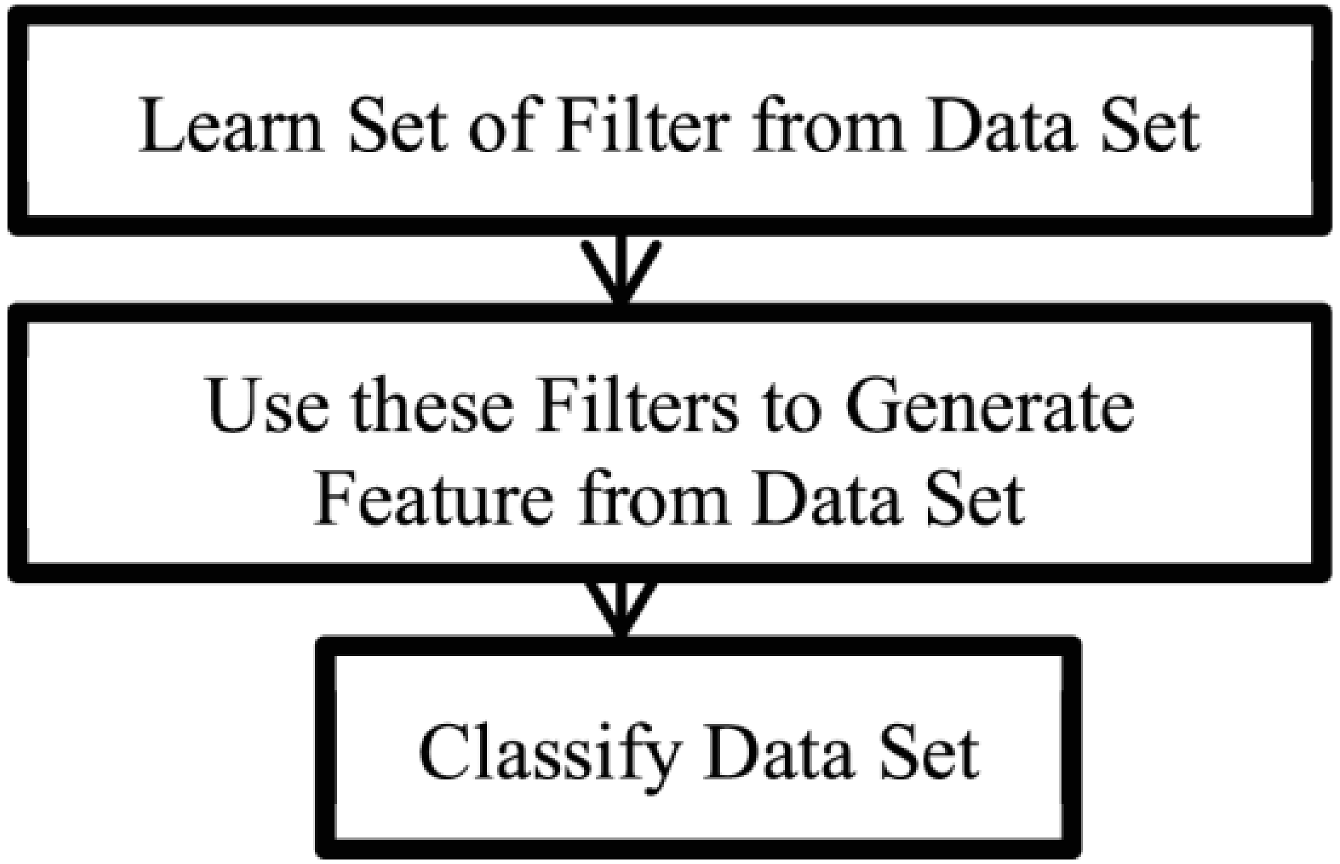
Materials centered on their spectral characteristics are classified by spectral analyst tool. It uses techniques like Binary Encoding, Spectral Angle Mapper (SAM) and Spectral Feature Fitting (SFF) and the output will be in the form of weighted score comparing the fit of the image spectra with that of reference spectra using SFF, with the help of least square method [4]. Between these two-spectrum high score denotes greater closeness or more similarity in the spectral features. The reference spectra are matched with the image spectra. Result of SFF in the RMS image output image is the measure of absorption feature depth.

D. Endmember Extraction

In both the spectral and spatial dimensions methodology is the limiting to locate, characterize and single out a few key spectral (endmembers). Once when the end members are handpicked using different techniques like Linearly transformation, SAM, Binary Encoding, the location and abundances can be mapped. By minimizing the dependency, these techniques drive the maximum information from the hyperspectral data.

Self Taught Learning For Hyperspectral Imaging

In HSI one of the biggest challenges is determining what types of features should be extracted from pixels. Deep convolutional Neural Networks widely adopted computer vision. So, in HSI deep learning is preferred. Figure represents the steps for Self-Taught Training. Basically, there are two self-taught learning techniques in the analysis of Hyperspectral image they are Multiscale Independent Component Analysis (MICA) and Stacked Convolutional Audio Encoder (SCAE)



-Steps for self-taught training

A. MICA

It learns the low-level feature representation and extracting filters from the image. The input for this technique is contrast stretched image. Edges of home or Outline of a long road are the examples for this technique. The low-level features learned by MICA yields a superior result compared with the SCAE.

B. SCAE

SCAE is a deep Neural Network approach which can potentially learn higher level non-linear features than MICA. It is made up of several auto encoders. Auto encoder is also a type of neural network that can be trained by an unsupervised manner to learn an encoded representation of data. SCAE model yielded the superior performance to MICA model, showing that higher level features can be advantageous in some cases.

Conclusion and Future Work

This article surveys the use of hyperspectral remote sensing for mineral exploration and also it is an effective tool for the identification and mapping of minerals. Currently, there is an increasing number sensor technologies which have encouraged researchers to use hyperspectral imagery. This study discussed about the basics of Hyperspectral and Multispectral data with their different resolution types. It mainly focused on AIG based hyperspectral methods that can be used for the mineral mapping using the Airborne and Spaceborne hyperspectral platforms. This study may form the basis for future research ideas in the development of hyperspectral imaging for mineral exploration.

FLOWCHART FOR CODING PART

1- Generate dataset from .mat files using Python script.

2-Train model for hypersepctral classification using Python Script.

3-Classify the image using Python script.

1-Generate dataset from .mat files using Python script

A-Import the necessary libraries

B-Define Global Variables

C-Load the IndianPines Dataset

D-Split data into train and test set.

E-Repeat for every label and concat

2-Train model for hypersepctral classification using Python Script..

A-Import the necessary libraries

B-Global Variables

C-Reshape into (number of samples, channels, height, width)

D-Convert class labels to one-hot encoding

E-Define the input shape

F-Number of filters

G-Define the model

3- Python script to classify the image

A-Import the necessary libraries
B-Define Global variables.
C-Load Indian Pines.
D-Load the model architecture and weights
E- Evaluate, find the accuracy and plot the confusion matrix.
F- Load the original image.
G- Calculate the predicted image

THANK YOU!