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Application of QGIS in Identification of Igneous Rocks Using Digital Image Histogram

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Abstract:
The spectral signatures of various igneous rocks were studied using histograms of satellite images and digital photographs of hand specimen of rocks. Comparison of histogram of digital image of hand specimen of a known rock was done with satellite image of a terrain of known geographical location and the igneous rocks were identified on the basis of similarity of image histograms. It was found on the basis of study of histograms of gabbro, granite, basalt and rhyolite that the shape of histogram of images cropped from Google Earth and those from images of hand specimens of known rocks and photographs of glazed rocks taken from internet were showing high degree of resemblance.

Key words: Image histogram, Digital image histogram, Igneous rock, Identification of Rocks

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I. Introduction

The categorization and identification of rocks are indispensable in geological research work. The traditional recognition methods are based on the physical, petrographical and chemical properties of rocks, which are used to identify rocks at macro- and micro-scales.

Freely available, high-resolution satellite imagery in Google Earth not only allows identification of research questions but is also critical in pre–field work mapping, targeting sites for field work. We used high resolution images in Google Earth to identify igneous rocks by comparing the image histograms of outcrops of igneous rocks extracted from Google Earth images with the images of rocks downloaded from internet.

A digital image/imagery of igneous rocks taken by remotely sensed special camera was used for classifying or trying to identifying by reflection of particular histograms. It has been having another way to uncover rock petrography or petrogenesis by remote sensing and GIS. The traditional recognition methods are based on the physical, petrographical and chemical properties of rocks as well as of each property has some sub-properties which are used to identify rocks at macro- and micro-scales. This method is not a method based on identification using single property to identifying perfectly but it has one of them like texture, structure or any other physical, petrological or chemical properties, which assist to researchers "to sense" things about the Earth surface.

The image processing techniques allow to extract from an image a set of numerical features, expressed as coded characteristics of the selected object, and used to differentiate one class of objects from another. The unit of information in a digitized image is the pixel and each pixel has properties of position and value; however, by itself, the knowledge of the position and value of a particular pixel generally does not convey any geological information, but it can be used to compare with the attributes of pixel values of a known object in order to identify an unknown object.

A digital image can be described as a two-dimensional array of integer values. Each value, referred to as a picture element or pixel, represents the average brightness inthe image at one location. The horizontal rows of pixels are referred to as lines, and the vertical columns as samples.

A digital imaging system measures the detected radiation within a specified spectral range (band) from each of many small areas collected in a predetermined pixel array format. Each pixel is assigned an integer value, termed a DN (digital number) that is related to the brightness of that area within the image. The integers fall within a discrete range. For instance, recorded in eight-bit format, the data range from 0 to 255, or 2 8 levels (0 = black or absence of radiation, 255 = white or saturation when dealing with black and white images).

The image processing techniques allow to extract from an image a set of numerical features, expressed as coded characteristics of the selected object, and used to differentiate one class of objects from another. The image processing techniques allow to extract from an image a set of numerical features, expressed as coded characteristics of the selected object, and used to differentiate one class of objects from another

Colour and texture are two different but complementary visual stimuli. Colour is related to the spectral content of the image, whereas texture refers to the variation of the intensity in a neighbourhood of pixels. As

used herein, the term "spectral content" refers to the energy distribution in the visible region of the electromagnetic spectrum.

Colour has been extensively used in image processing . Most commonly the colour content of an image is conveyed by three channel digital images, such as the RGB images used in our investigation. Colour based features are invariant to translation and/or rotation of the pixels in an image, and onlyslightly dependent on the viewing angle. Histogram based methods rely on the probability distribution of the colours of a predefined palette.

The histogram of an image is a graphical representation of the frequency of pixel intensity occurrence in the image. In an 8-bit grayscale image, such as a scanned document, 256 grayscale values are possible. Another image acquisition method, for instance, a digital camera, might produce 16-bit images, which results in 65,536 possible grayscale values. A large peak in an image histogram identifies a group of common grayscale values, whereas a valley indicates that one or several adjacent grayscale values are less common in the image. In a color image, the individual red, green, and blue (RGB) color components can be similarly viewed as histograms.

A histogram is a very important tool in Image processing. It is a graphical representation of the distribution of data. An image histogram gives a graphical representation of the distribution of pixel intensities in a digital image. The x-axis indicates the range of values the variable can take. This range can be divided into a series of intervals called bins. The y-axis shows the count of how many values fall within that interval or bin. When plotting the histogram we have the pixel intensity in the X-axis and the frequency in the Y-axis. As any other histogram we can decide how many bins to use.

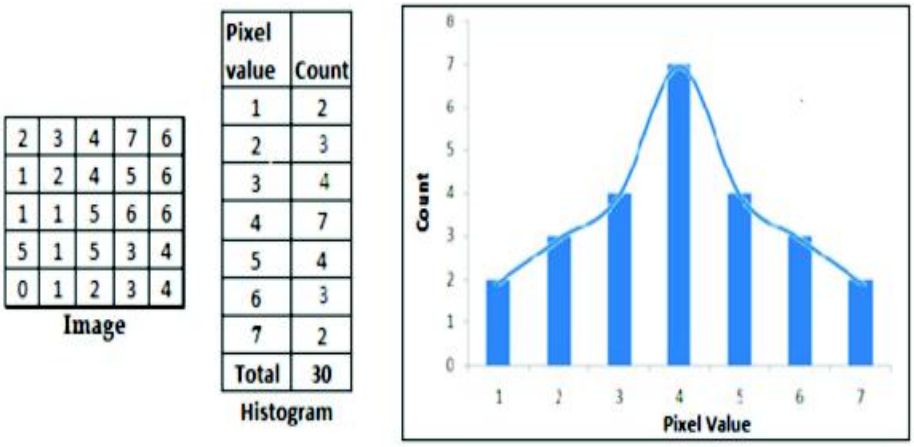
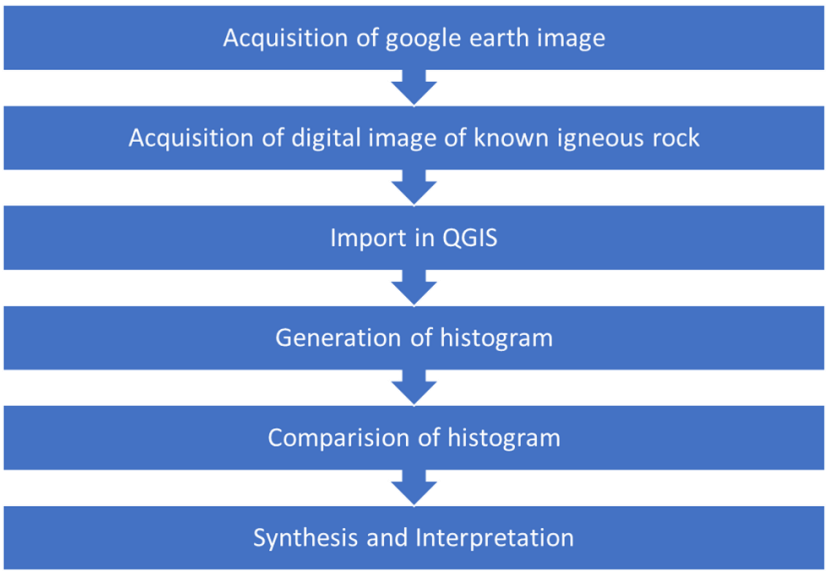


Figure- 1: Table in left is showing digital number of a hypothetical image. Central table shows frequency of occurrence of each digital number. Figure at the right is the graphical representation i.e. histogram of the central table.

A histogram can be calculated both for the gray-scale image and for the colored image. In the first case we have a single channel, hence a single histogram. In the second case we have 3 channels, hence 3 histograms. Calculating the histogram of an image is very useful as it gives an intuition regarding some properties of the image such as the tonal range, the contrast and the brightness.In an image histogram, the x-axis represents the different color values, which lie between 0 and 255, and the y-axis represents the number of times a particular intensity value occurs in the image.

II. Methodology

Igneous rocks were used in the present study because igneous rock is primary rock and is not weathered form of any other rock. Igneous rock is formed through the cooling and solidification of magma or lava, with or without crystallization, either below the surface as intrusive(plutonic) rocks or on the surface as extrusive(volcanic) rocks. The methodology of present work can be summarized as follows: -



Acquisition of image from imagery: -Using Google Earth Pro, image of an outcrop of a known rock from a locality is acquired along with its coordinates.
Acquisition of image of the same rock from internet: -Photographs of same rock and glazed rock was download through the Googlesearch engine.
Processing of images in QGISSoftware: - The three types of images (Google Earth image of the outcrop, image of the same rock and image of the same rock having glazed surface were cropped and processed in QGIS software.Version 2.0.1.
Histogram creation: -Different histogram patterns were obtained for different images, using QGIS software.
Comparison of Histograms and preparation of attribute tables: -The histograms were compared and tables for three colors with their Frequency peak value,Pixel value and X &Y values were prepared.
Synthesis and Interpretation: -The resultant tables and histograms of each rock type were observed and interpreted.

The present studies were carried out on images of four rock types namely basalt, gabbro, rhyolite and granite. The observations made during the studies are presented in next few paragraphs. They include brief description of each rock, its images and respective histograms.

Basalt:- Basalt is a dark-colored, fine-grained, igneous rock composed mainly of plagioclase and pyroxene minerals. It most commonly forms as an extrusive rock, such as a lava flow, but can also form in small intrusive bodies, such as an igneous dike or a thin sill. It has a composition similar to gabbro. The difference between basalt and gabbro is that basalt is a fine-grained rock while gabbro is a coarse-grained rock.For large scale identification we use Google earth image for basalt for lava flow in surface so we find a location. Basalt underlies more of Earth's surface than any other rock type. Most areas within Earth's ocean basins are underlain by basalt. Although basalt is much less common on continents, lava flows and flood basalts underlie several percent of Earth's land surface.

A part of Google Earth imagery with known locality of occurrence of basalt was acquired and cropped and histogram was created using QGIS as follows
Place:-Lava flow in 12 may 2018 Pahoa, HI, USA
Longitude:-$19^0$28’25.36” N, **Latitude:-**$154^0$52’18.93”W, **Elevation:-**397 ft

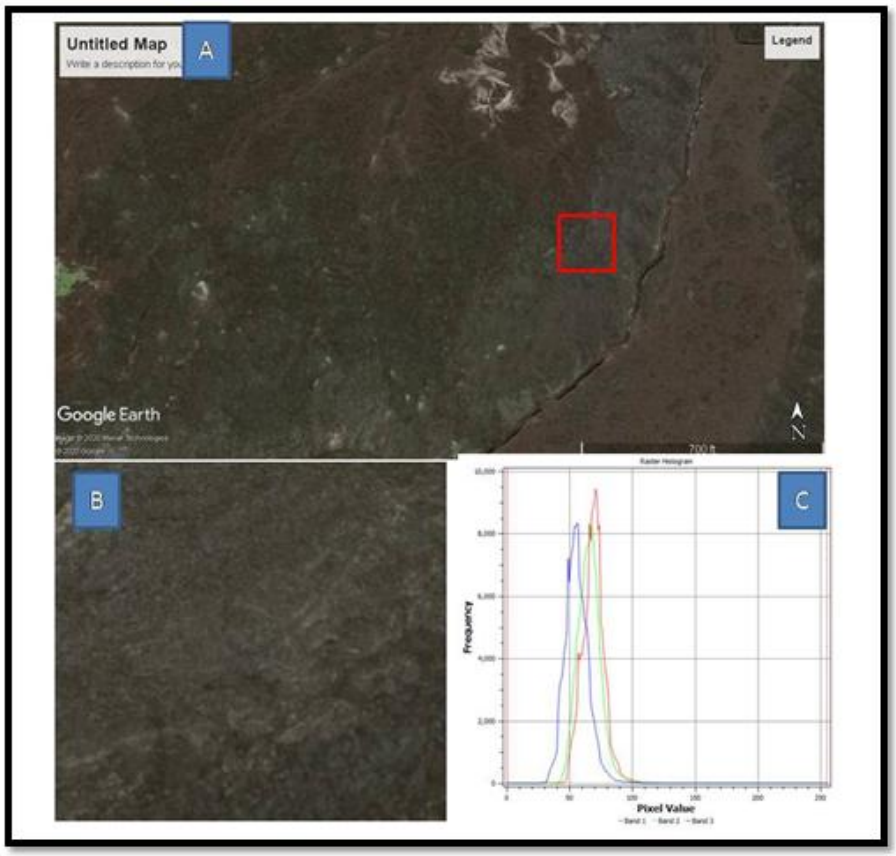


Figure 2 (A) Given true color Google earth image is depicting basaltic lava flow from Pahoa, HI, from USA , **(B)** and **(C)** Cropped image of image **(A)** and histogram respectively.

Histograms of photographs of hand specimens of basalt and glazed images of basalts downloaded from internet were also plotted. They are shown below.

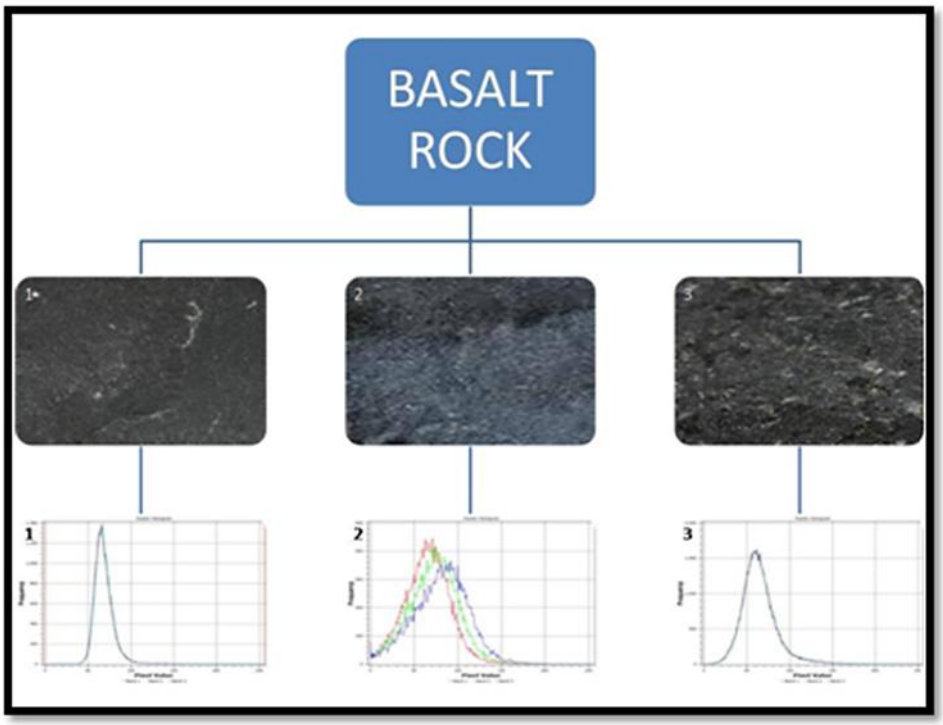


Figure3 :- Images of various hand specimens ofbasalt and 1, 2 and 3 are showing various basalt rock and their respective histograms

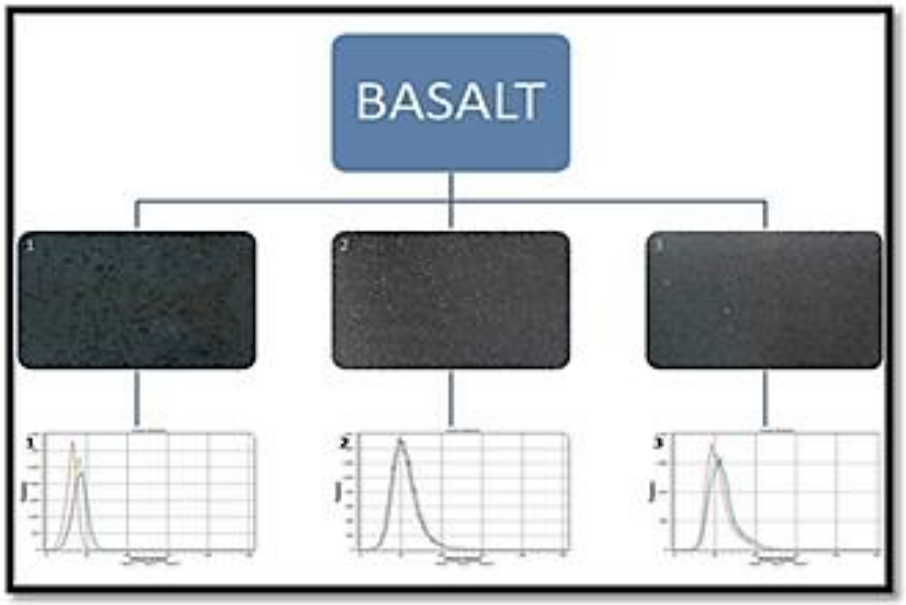


Figure 4 :- Glazed images of basalts downloaded from internet and their respective histograms

Gabbro: - Gabbro is a coarse-grained, dark-colored, intrusive igneous rock. It is usually black or dark green in color and composed mainly of the minerals plagioclase and augite.Gabbro is composed mainly of calcium-rich plagioclase feldspar (usually labradorite or bytownite) and pyroxenes (usually augite). Minor amounts of olivine might also be present in the rock. Gabbros are equivalent in composition to basalts. The difference between the two rock types is their grain size. Basalts are extrusive igneous rocks that cool quickly and have fine-grained crystals. Gabbros are intrusive igneous rocks that cool slowly and have coarse-grained crystals.A part of Google Earth imagery with known locality of occurrence of Gabbro was acquired and cropped and histogram was created using QGIS as follows

Place:-Zuma Rock, Nigeria**Longitude:-**9^0 07'41.37"N **Latitude:-**$7^0$14'16.51"E **Elevation:-** 1323ft

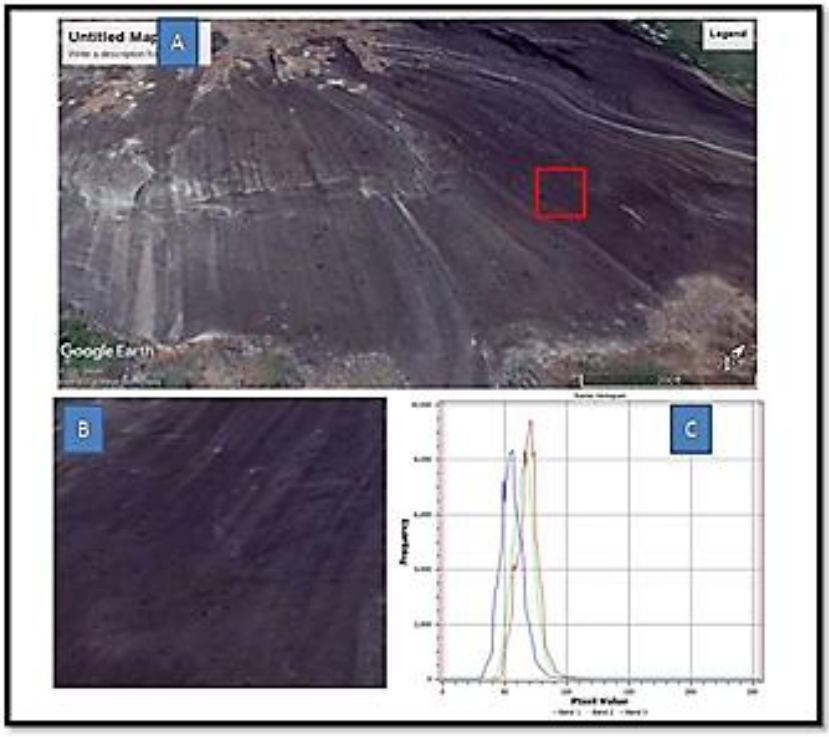


Fig 5(A) Given Google earth image is depicting intrusive Gabbro rock from Zuma rock, Nigeria **(B)** and **(C)** Cropped image of image **(A)** and histogram respectively.

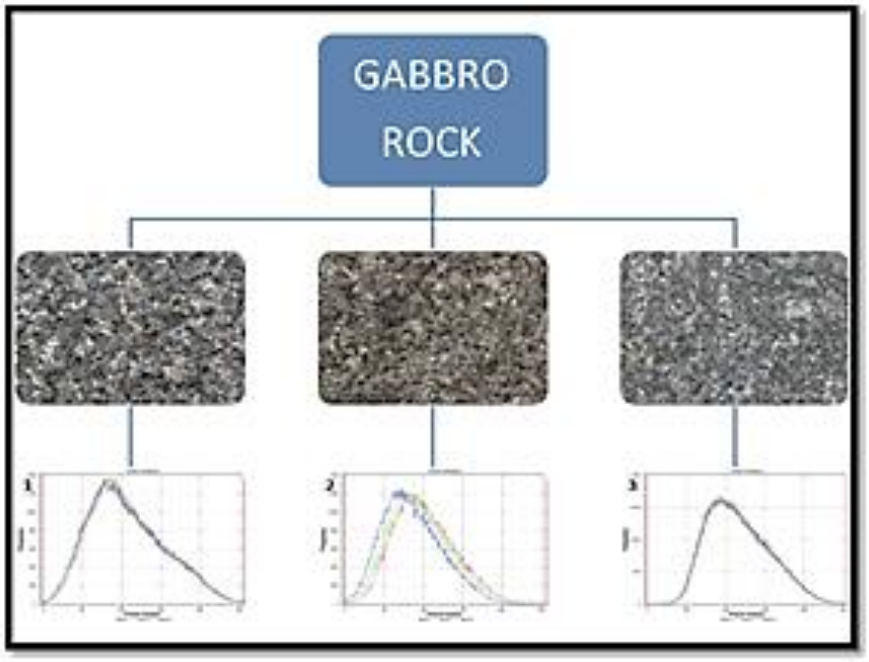


Figure 6 Photograph of various hand specimens of gabbro and their histogram.

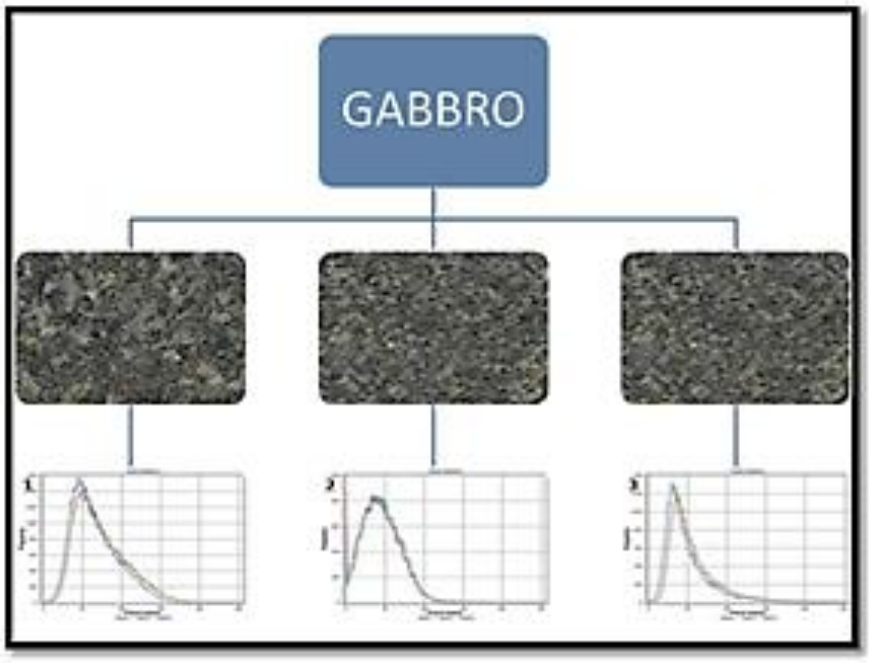


Figure 7 Photograph of Glazed gabbro rocks with their histogram.

Rhyolite:-Rhyolite is an extrusive igneous rock with a very high silica content. It is usually pink or gray in color with grains so small that they are difficult to observe without a hand lens. Rhyolite is made up of quartz, plagioclase, and sanidine, with minor amounts of hornblende and biotite. Trapped gases often produce vugs in the rock. These often contain crystals, opal, or glassy material.A part of Google Earth imagery with known locality of occurrence of Rhyolitewas acquired and cropped and histogram was created using QGIS as follows
Place:-Ghost town near Rhyolite mountain, Nevada, USA
Longitude:- $36^0$54’27.25”**N** **latitude**:-$116^0$49’42.22”W **Elevation**:-3877 ft

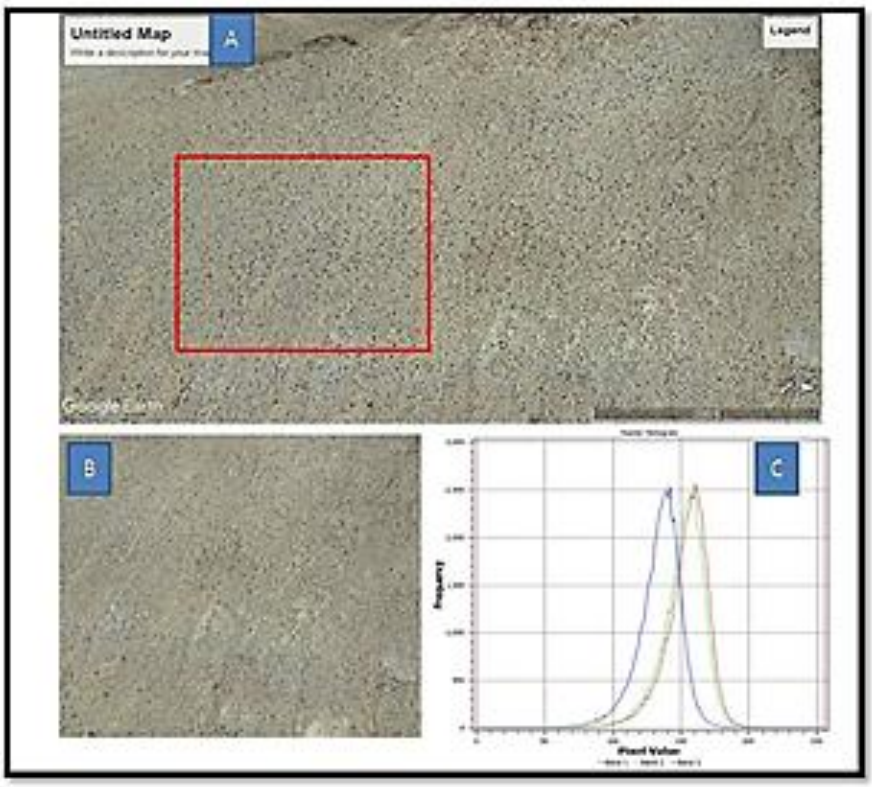


Figure - 8(A) Given Google earth image is depicting intrusive Rhyolite rock from ghost town near Rhyolite mountain, Nevada, USA **(B)** and **(C)** Cropped image of image **(A)** and histogram respectively.

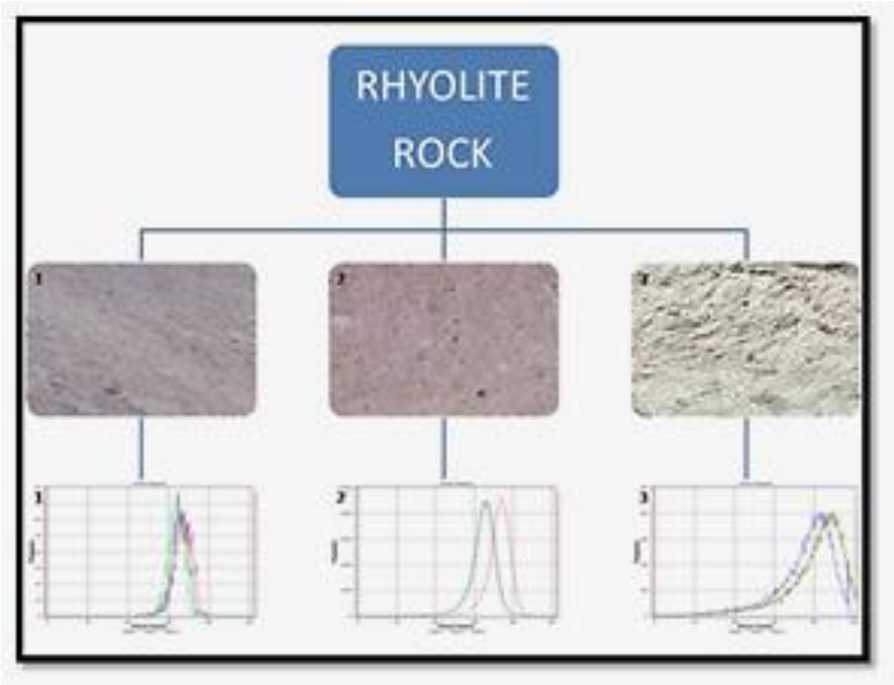


Figure 9 Photograph of various hand specimens of Rhyolite with their histogram.

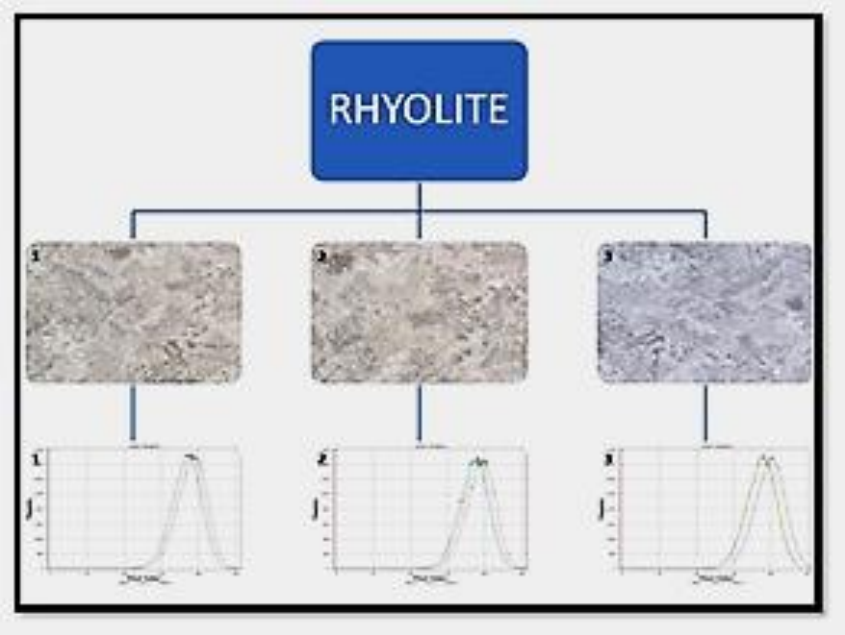


Figure 10 Photograph of glazed rhyolite rocks with their histogram.

Granite:-Granite is a light-colored igneous rock with grains large enough to be visible with the unaided eye. It forms from the slow crystallization of magma below Earth's surface.Granite is composed mainly of quartz and feldspar with minor amounts of mica, amphiboles, and other minerals. This mineral composition usually gives granite a red, pink, gray, or white color with dark mineral grains visible throughout the rock.A part of Google Earth imagery with known locality of occurrence of Granite was acquired and cropped and histogram was created using QGIS as follows

Place:-Dongargarh, Chhattisgarh, India

Longitude:-21^{0}10’39.66”**N** **latitude**:-80^{0}44’59.72”E **Elevation**:-1573 ft

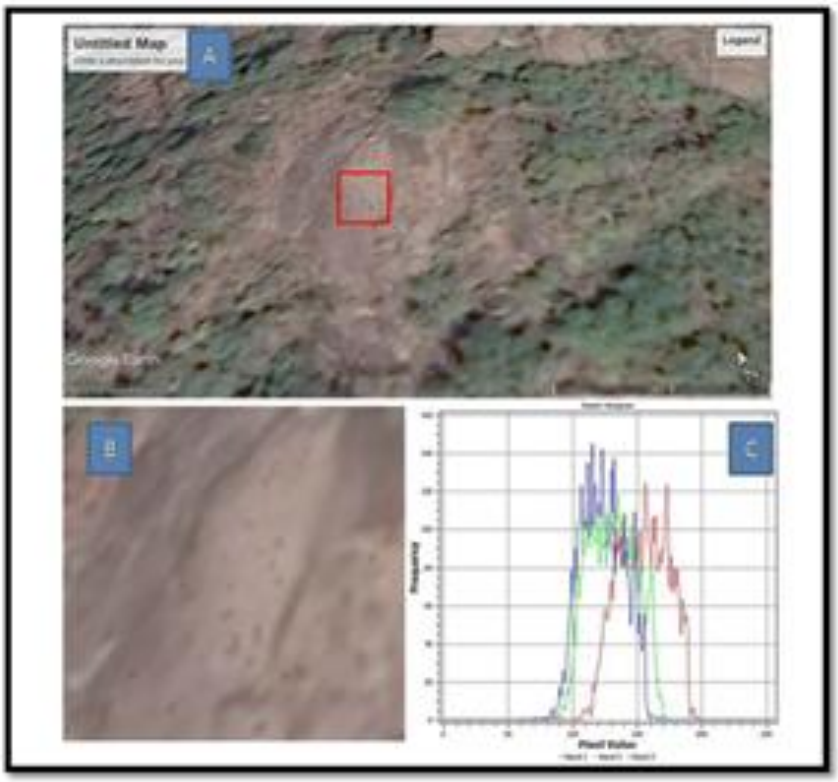


Figure11 (A) Given Google earth image is depicting intrusive granite rock from Dongargarh, Chhattisgarh, India **(B)** and **(C)** Cropped image of image **(A)** and histogram respectively.

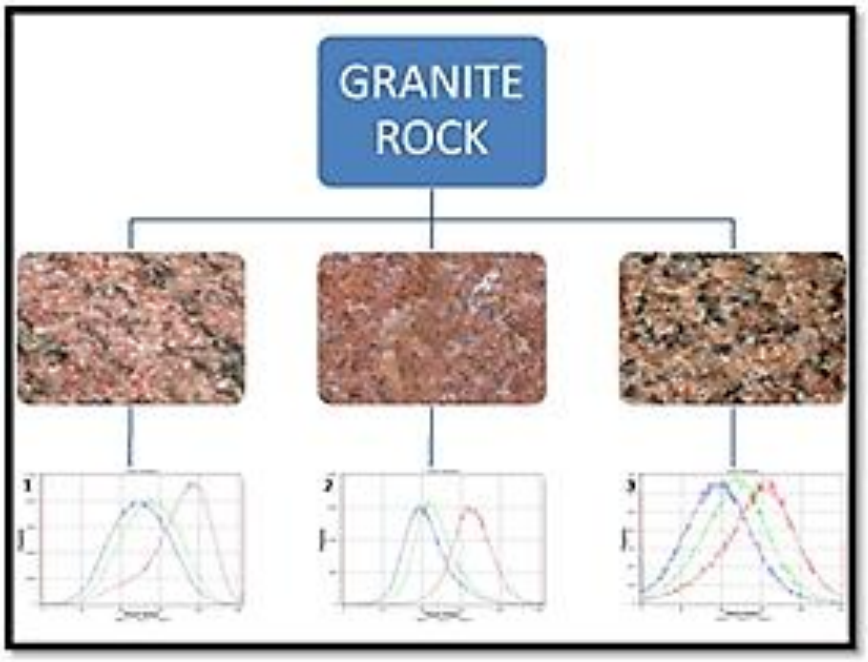


Figure 12 Photograph of various fresh field samples ofgranite with their histogram.

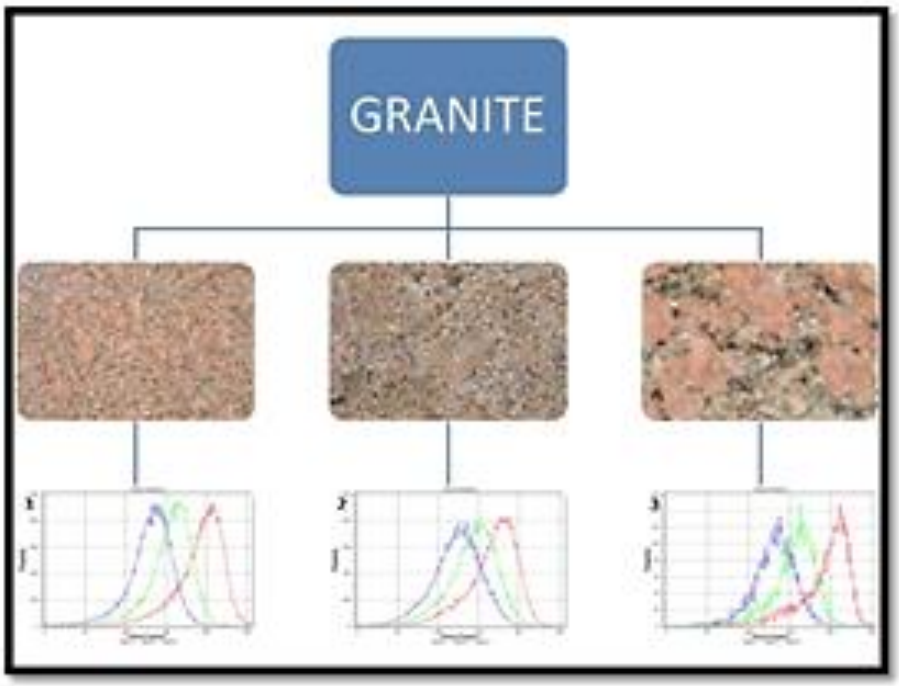


Figure 13 Photograph of Glazed Granite rocks with their histogram.

III. Synthesis of Data

In this section comparison of various histograms and observed values in the histograms of various rock types are presented below.

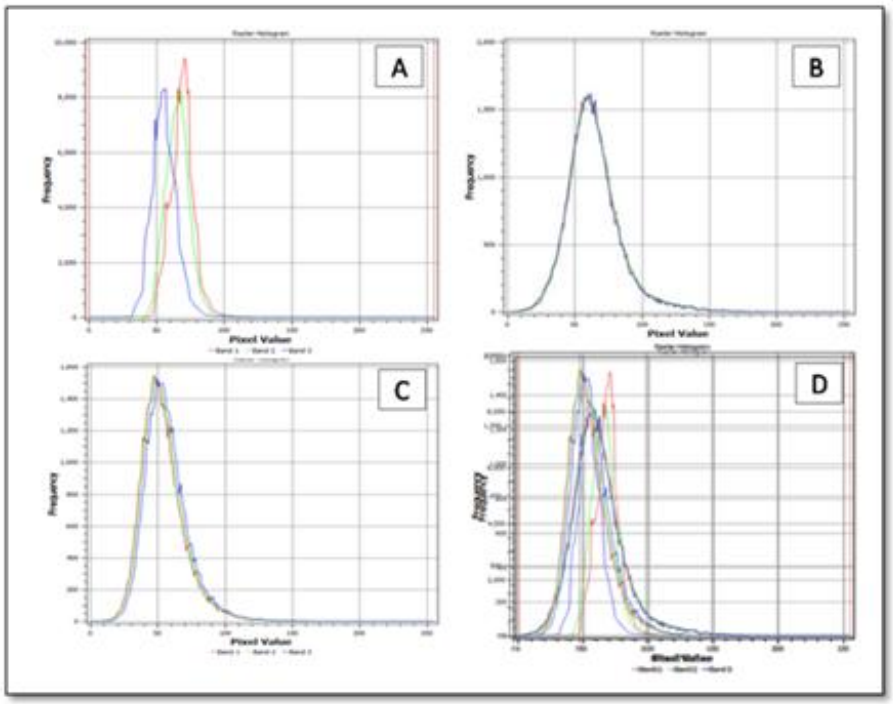


Figure14 : (A) -histogram of Google satellite image of Basalt **(B) -** histogram of basalt hand specimen rock photo **(C) -** histogram of basalt glazed photo **(D) -** This figure shows that the **(A), (B)** and **(C)** histogram curve through overlapping show same pattern .

Table :1 The attributes of peak point frequency, Pixel values and X-Y values observed in 4 histograms of basalt.

BASALT										
Figure	Histogram location	Red graph pattern			Green graph pattern			Bluegraph pattern		
		Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y
A	Google Satellite Image	**9500**	**40-100**	**70 9500**	**8500**	**40-105**	**70 8500**	**8400**	**30-95**	**60 8400**
B	Hand Specimen	**1600**	**10-150**	**65 1600**	**1600**	**10-150**	**65 1600**	**1600**	**10-150**	**65 1600**
C	Glazed Image	**1500-1550**	**15-130**	**48 1550**	**1500-1550**	**15-130**	**50 1550**	**1500-1550**	**15-130**	**50 1550**
D	Overlapping Histogram	**Min-1500 Max-9500**	**10 150**	**48 9500**	**1500 8500**	**10 150**	**50 8500**	**1500 8400**	**10 150**	**50 8400**

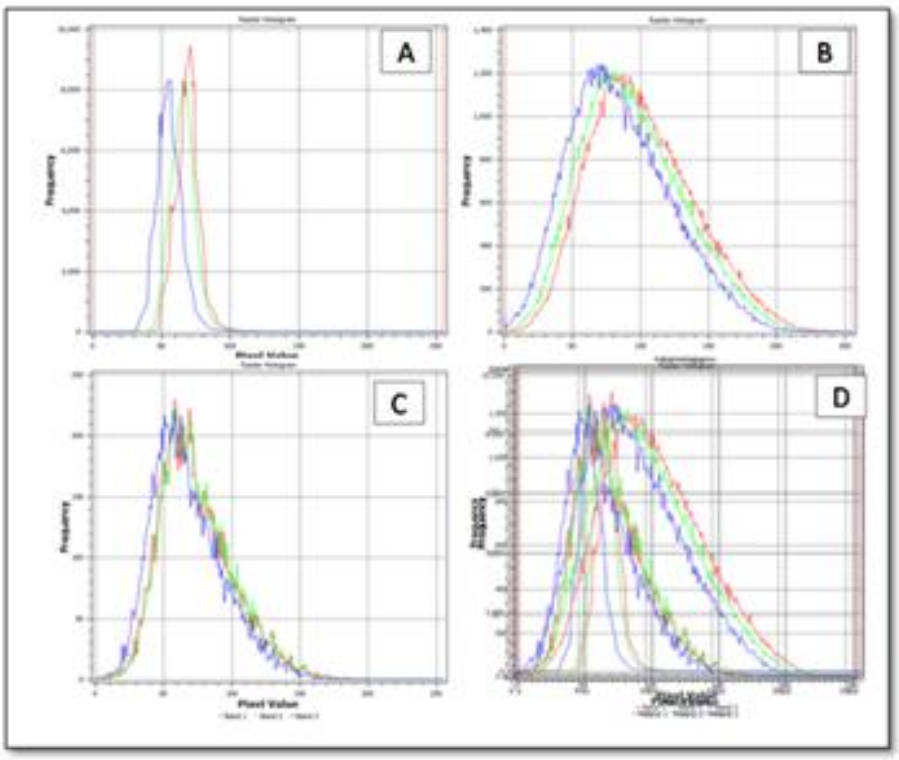


Figure15 : (A) -Histogram of Google satellite image of gabbro **(B) -** Histogram of gabbro hand specimen rock photographs **(C) -** Histogram of glazed photo of gabbro **(D) -** This figure shows that the **(A), (B)** and **(C)** histogram curve through overlapping show same pattern.

Table :2 The attributes of peak point frequency, Pixel values and X-Y values observed in 4 histograms of gabbro.

Gabbro										
Figure	Histogram location	Red graph pattern			Green graph pattern			Bluegraph pattern		
		Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y
A	Google Satellite Image	9500	40-100	**70 9500**	**8500**	**40-105**	**70 8500**	**8400**	**30-95**	**60 8400**
B	Hand Specimen	**11**00-1200	**10**-220	**90 1150**	**1200**	**5-215**	**80 1200**	**1200-1250**	**0-200**	**70-1250**
C	Glazed Image	**230**	**10-160**	**60 230**	**220**	**10-160**	**50 220**	**220**	**10-160**	**50 220**
D	Overlapping Histogram	**Min –230 Max-9500**	**10 220**	**60 9500**	**220 8500**	**5 215**	**50 8500**	**220 8400**	**0 200**	**50 8400**

Rhyolite:-These are histograms of Rhyolite rock through the Google satellite image, hand specimen and glazed photo respectively.

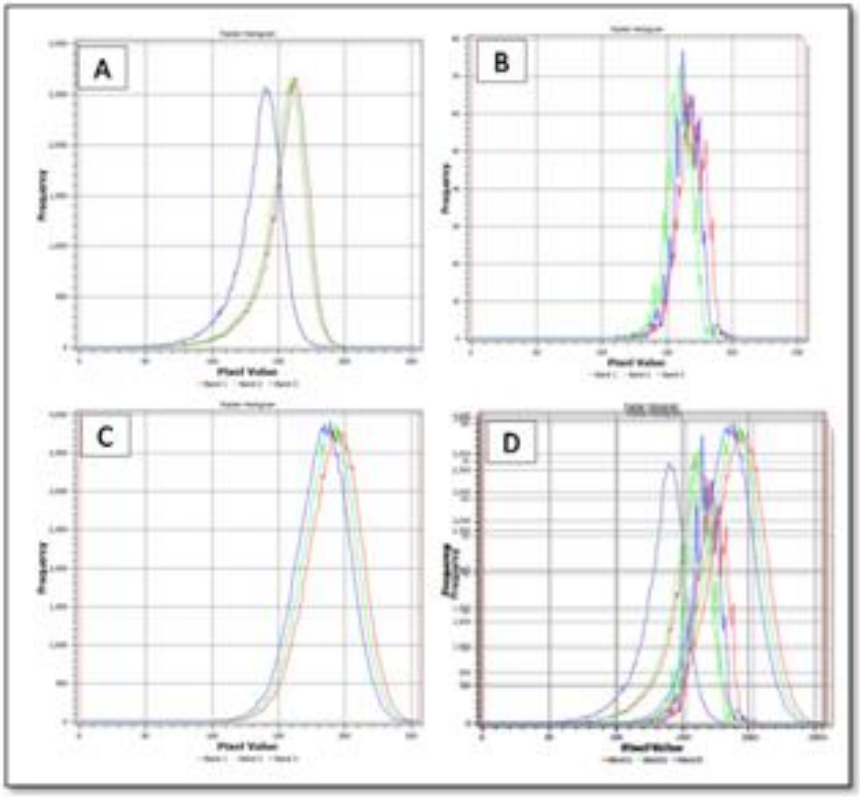


Figure16 : (A) -Histogram of Google satellite image of rhyolite **(B) -** Histogram of rhyolite hand specimen photographs, **(C) -** Histogram of glazed photographs of rhyolite **(D) -** This figure shows that the **(A), (B)** and **(C)** histogram curve through overlapping show same pattern .

Table :3 The attributes of peak point frequency, Pixel values and X-Y values observed in 4 histograms of rhyolite.

Rhyolite										
Figure	Histogram location	Red graph pattern			Green graph pattern			Bluegraph pattern		
		Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y
A	Google satellite image	2650	80-200	**170 2650**	2650	80-200	**170 2650**	**2550**	**60-180**	**140 2550**
B	Hand specimen	**66**	**130-200**	**170 66**	**74**	**120-190**	**165 74**	**77**	**120-190**	**160 77**
C	Glazed image	**3750**	**115-250**	**190-3750**	**3800**	**115-245**	**185 3800**	**3900**	**110-240**	**180 3900**
D	Overlapping histogram	**Min-66 max-3750**	**80 250**	**66 3750**	**74 3800**	**80 245**	**74 3800**	**77 3900**	**60 240**	**77 3900**

Granite:- These are histograms of granite obtained from the Google satellite image ,hand specimen and glazed photo respectively.

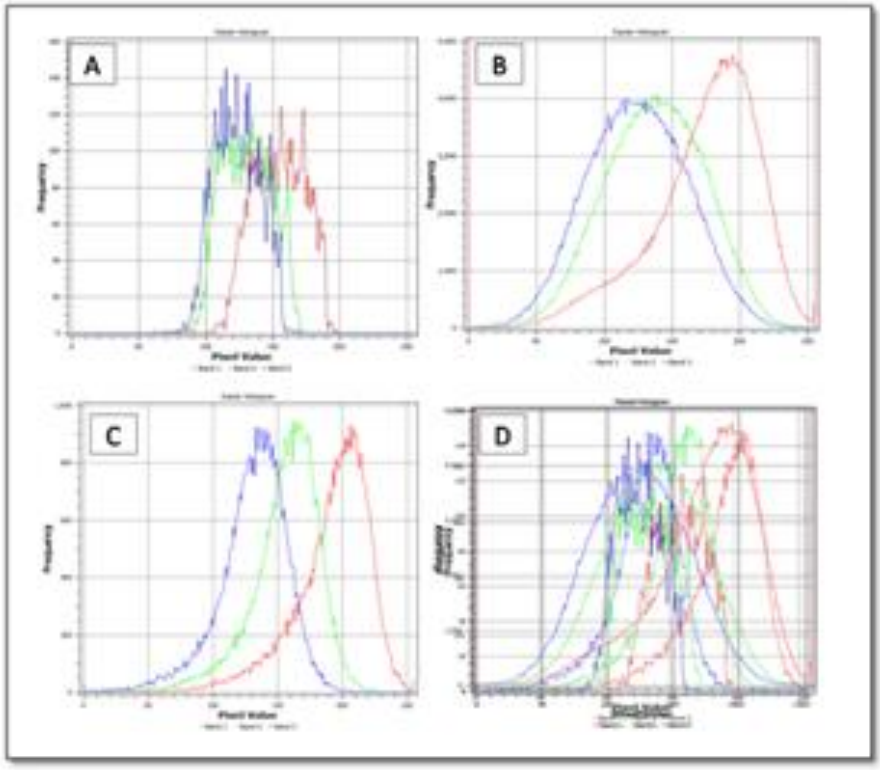


Figure17 : (A) -Histogram of Google satellite image of granite **(B) -** Histogram of granite hand specimen photographs **(C) -** Histogram of glazed photographs of granite **(D) -** This figure shows that the **(A), (B)** and **(C)** histogram curve through overlapping show same pattern .

Table :4 The attributes of peak point frequency, Pixel values and X-Y values observed in 4 histograms of granite.

Granite										
figure	Histogram location	Red graph pattern			Green graph pattern			Bluegraph pattern		
		Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y	Frequency Peak point	Pixel value	X and Y
A	Google satellite image	125	105-200	**160-125**	**115**	**85-170**	**140 115**	**145**	**80-160**	**120 145**
B	Hand specimen	**4850**	**45-250**	**190 4850**	**4000**	**40-235**	**135 4000**	**4000**	**20-230**	**120 4000**
C	Glazed image	**900**	**80-250**	**210 900**	**950**	**60-220**	**170 950**	**900**	**40-200**	**180 900**
D	Overlapping histogram	**Min-125 Max-4850**	**45 250**	**125 4850**	**115 4000**	**40 235**	**115 4000**	**145 4000**	**20 230**	**120 4000**

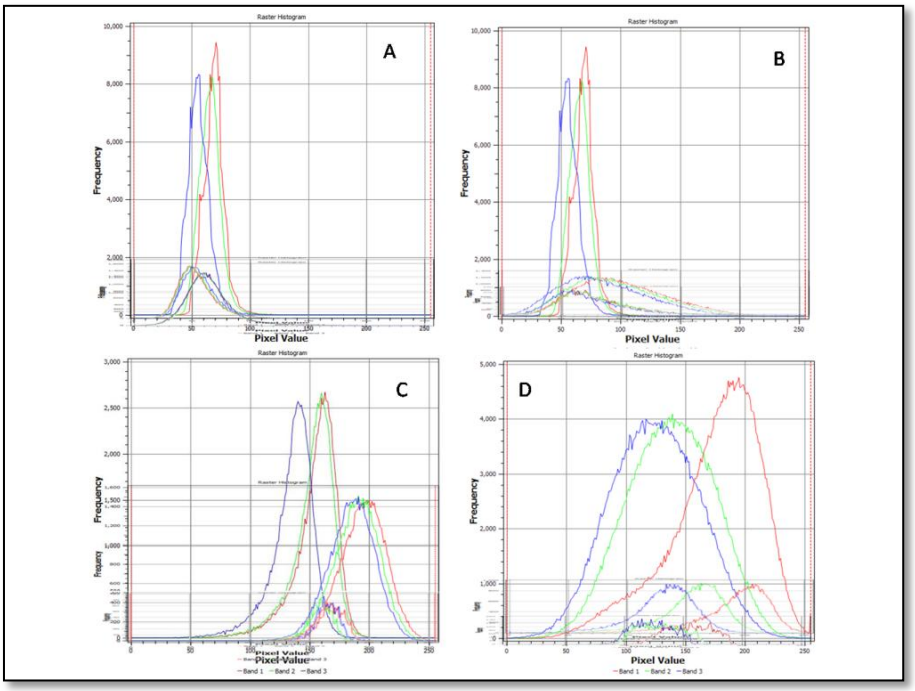


Fig:18 (A) Overlap histogram of basalt. **(B)** Overlap histogram of Gabbro **(C)** Overlap histogram of Rhyolite . **(D)** Overlap histogram of Granite.

IV. Discussion and Conclusion

The histograms of photographs of hand specimens of rocks, glazed rocks and their satellite image were compared and it led to following observations

1. The rocks in their satellite image, hand specimen and glazed photo exhibit same pattern in histogram curve.
2. The equivalent rocks like basalt and Gabbro show similar pattern of histogram because the Basalt is volcanic equivalent of gabbro rock. Similarly, Rhyolite and Granite show similar histogram pattern.
3. The histogram of same rocks images, cropped in various sizes, are depicting similar pattern but different frequency.

It was found on the basis of study of histograms of gabbro, granite, basalt and rhyolite that the shape of histogram of images cropped from Google Earth and those from images of hand specimens of known rocks and photographs of glazed rocks taken from internet were showing high degree of resemblance.Thus application of QGIS and remote sensing can serve as an effective tool for identification ofigneous rocksafter development of standard dataset and application of necessary corrections.

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Rock Images:-

[13]. BASALT:-
https://www.google.com/search?q=basalt+rock+images&espv=2&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjs0Njov8HnAhXczTgGHdhkDJwQ_AUoAXoECA8QAw&biw=1366&bih=667
[14]. GABBRO:-
https://www.google.com/search?q=gabbro+rock+images&tbm=isch&ved=2ahUKEwiSkqzqv8HnAhVKE7cAHTXdDSMQ2-cCegQIABAA&oq=ga+rock+images&gs_l=img.1.0.0i7i30j0i7i5i30j0i8i7i30l8.45958.47974..50620...0.0..0.162.1037.0j8.....0....1..gws-wiz-img.....0i67j0.O_PHtlahHrc&ei=Hmw-XpKLOcqm3LUPtbq3mAI&bih=667&biw=1366
[15]. RHYOLITE:-
https://www.google.com/search?q=rhyolite+rock+images&tbm=isch&ved=2ahUKEwjfv8GDwMHnAhUUMLcAHXTABZ0Q2-cCegQIABAA&oq=rh+rock+images&gs_l=img.1.0.0i7i30.74367.79189..81595...1.0..0.137.1337.0j11.....0....1..gws-wiz-img.....0i67j0.aBJW7DWkuc4&ei=U2w-Xp_KK5Tg3LUP9ICX6Ak&bih=667&biw=1366
[16]. GRANITE:-
https://www.google.com/search?q=granite+rock+images&tbm=isch&ved=2ahUKEwin0ZCrwMHnAhVFJrcAHVZQAl0Q2cCegQIABAA&oq=gr+rock+images&gs_l=img.1.0.0i7i30l5j0i7i5i30l4j0i8i7i30.43247.45040..47475...0.0..0.188.1259.1j9.....0....1..gws-wiz-img.....0i67j0.Thr1czjjDbM&ei=pmw-XqfmMMXM3LUP1qCJ6AU&bih=667&biw=1366

Glazed Image:-

[17]. BASALT:-
https://www.google.com/search?q=basalt+polished&espv=2&source=lnms&tbm=isch&sa=X&ved=2ahUKEwj5kKW66JbnAhUJOSsKHWZqAA0Q_AUoAXoECA8QAw&biw=1366&bih=629
[18]. RHYOLITE:-
https://www.google.com/search?espv=2&biw=1366&bih=667&tbm=isch&sa=1&ei=XQsoXpaHNo2o9QPps4S4BQ&q=rhyolite+polished&oq=RHYO+polished&gs_l=img.1.0.0i7i30j0i8i7i30.93947.97244..99528...0.0..0.439.2647.0j7j4-4.....0....1..gws-wiz-img.....0i67j0i8i30j0j0i7i5i30.bMs4hhwrg18
[19]. GRANITE:-
https://www.google.com/search?espv=2&biw=1366&bih=667&tbm=isch&sa=1&ei=wgsoXqaOHdLarQGf3LroDA&q=granite+polished&oq=GRA+polished&gs_l=img.1.0.0i7i30l10.24053.28545..30756...0.0..0.147.1579.0j12.....0....1..gws-wiz-img.....0i67j0i8i30j0i8i7i30j0.-JjgjP4TNnw
[20]. GABBRO:-
https://www.google.com/search?espv=2&biw=1366&bih=667&tbm=isch&sa=1&ei=CgwoXt6NKMSm9QOqm4yYAw&q=gabbro+polished&oq=GA+polished&gs_l=img.1.2.0i7i30l8j0i7i5i30l2.23484.25316..28451...0.0..0.155.1600.0j12.....0....1..gws-wiz-img.....0j0i67.BZpgR93H47Q

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