HYPERSPECTRAL STUDY AND INTEGRATION OF PETRO-CHEMICAL SIGNATURES ON CORUNDUM BEARING LITHO-UNITS AROUND MADDUR, MANDYA DISTRICT, KARNATAKA, INDIA

Maruthi N.E[1], Basavarajappa H.T[1], Manjunatha M.C[2] & Harshavardhana A.S[3]

[1]Department of Studies in Earth Science, Centre for Advanced Studies in Precambrian Geology, University of Mysore, Manasagangothri, Mysuru – 570 006, Karnataka, India

[2]Department of Civil Engineering, Maharaja Institute of Technology, Tandavapura, Mysuru- 571 302

[3]Department of Mines and Geology, Govt. of Karnataka

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ABSTRACT: *Corundum is one of the stable gemstone mineral and second hardest after diamond. the mineral unreacted by acids. Granitic rocks are exposed throughout the world in the Precambrian Shields which have evoked considerable debate, discussion and controversy among eminent Petrologists and Geochemists. Precambrian basement rocks of Karnataka composed of active and dynamic geological setting with economic mineral deposits and variety of gemstones. Corundum is a rock form mineral its gem varieties, Ruby and Sapphire occurs deep in the lithosphere in a regime of extremely high pressures and temperature conditions. These gemstones were noticed all along the lithological contacts of Green stone and Schist Belts, adjacent to younger granites and granitoids of Dharwar Craton in Southern Karnataka. High Aluminium oxide (85%) containing Corundum Gem varieties bearing lithounits were collected in contact zones of pink granite and amphibolite schist around Madduru taluk of Mandya district. Basement gneiss and acid volcanic rocks were also noticed around these gem varieties. The present research to integrate the geological, petrochemical and Hyperspectral signature using advent high-tech tools of Spectro- Radiometer (Spectral Evolution SR-3500) instrument, DARWin SP.V.1.3.0 and ArcGIS software's. The spectral signatures of the collected samples were derived in laboratory environment to achieve better accuracy. Physico-chemical and optical properties of the collected samples were observed through Spectral signatures studies; while Petrographic study reveals the detailed description of lithological contacts and mineralized zones. The present study aims to characterize the spectral behavior of Corundum and associated rocks of the study area to bring out diagnostic features and better discrimination of gemstone verities and other minerals. The final results highlight the spectral characters of corundum and associated rocks for better mapping around Madduru taluk of Mandya district and similar terrains of Karnataka State.*

Key Words: *Hyperspectral; Petro-chemical Signatures; Corundum; Madduru.*

1. INTRODUCTION

Corundum is a crystalline mineral that occur in different colours, such as, white, grey, blue,green, red, yellow, or brown-based on impurities present (Basavarajappa and Maruthi, 2018). It is usually found in metamorphosed shales and limestones, in veins, and in some igneous rocks. It is used as an abrasive and as gemstone (Basavarajappa et al., 2018). As gems the red variety is called ruby and blue, sapphire. mineral composed of aluminium oxide ($Al2O3$). with a crystal structure of hexagonal (rhombohedral). The ruby and sapphire are coloured crystals of corundum, whose mineral composition on chemical analysis is shows consist of earth alumina in crystallised state nearly in pure condition (Swaminath and Ramakrishnan, 1981). These gems have almost invariably discovered in the beds of rivers. In addition to its hardness of up to 9 on Mohs scale, corundums density of 4.02 g/cm3 is unusually high for a transparent mineral composed of low atomic mass elements, such as, aluminium and oxygen (Maruthi and Basavarajappa, 2018). Corundum is a exceptionally hard and tough material and second - hardest mineral, after diamond and moissanite (Basavarajappa and Maruthi, 2018). Among natural obressive minerals, corundum forms one of the most important, on account of its great hardness being only next to that of diamond (Maruthi et al., 2018). Reddish Corundum crystals occur in a north-south trending linear tract of 30 km length extending from Kupya of T.Narsipur taluk of Mysore district to Mandya. Important deposits are reported from Satanur near Mandya, Erehalli, Kirangur and Ramanahalli areas. Another tract with corundum deposits extends from about 60 km. from near Ramanagaram to Malavalli. Only a small quantity of this minaral is being used in the state, for industrial purpose (Swaminath and Ramakrishnan, 1981). The study area Maddur comes to Mandya District. The district exposes mainly comprise rocks belong to Sargur group, Peninsular Gneissic

Complex (PGC), Banded Magnetite Quartzite (BMQ), granite, and basic and younger intrusives of the Precambrian era (Ramakrishnan and Vaidyanadhan., 2008). Field investigations and Petrography of the host rocks were studied in detail with Geochemical, Physical and Optical properties and characteristics in the laboratory. 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 are studied as described by Hunt and Salisbury (1970), Hunt et al., (1971), Hunt and Ashley (1979) and (Graham Hunt 1977), the fresh or weathered surface of iron metallic elements causes strong absorptions in Visible and Near Infrared region of electromagnetic wavelength.

2. STUDY AREA

Maddur is a town in Mandya district in the Indian state of Karnataka. It lies on the banks of the river Shimsha. It is 82 kilometers from the state capital Bangalore and 60 kilometers from Mysore. The original name of this place was Arjunapuri. During Tippu Sultan's rule this place was used to make ammunitions, and rockets. Thereafter, the place came to be known as Maddur (Maddu in general means 'medicine' or 'chemical'). The study area is located in between 12^{0}31.00” to 12^{0}43.00’ North latitude and 76^{0}57.00’ to 77^{0}10.00” East longitude with an aerial extent of 1045.39 sq km (Fig.1). It has an average elevation of 653 metres above MSL. Maddur area covering mainly red & block soils associated with metamorphosed granitic gneiss composition, ultramafics, corundum bearing litho units (CGWB, 2012).

Table.1. Samples collected and its Location

Sl No	Samples Name	Villages name	Latitude	Longitude
CM-01	Corundum	Kesthur	11^{0}41.929’	77^{0} 03.292’
CM-02	Corundum	Hanumanthapura	12^{0}39.377’	77^{0} 04.437’
CM-03	Corundum	Maddur	12^{0}32.920’	77^{0} 06.651’

Note: **CM- C**orundum at **M**adhugiri

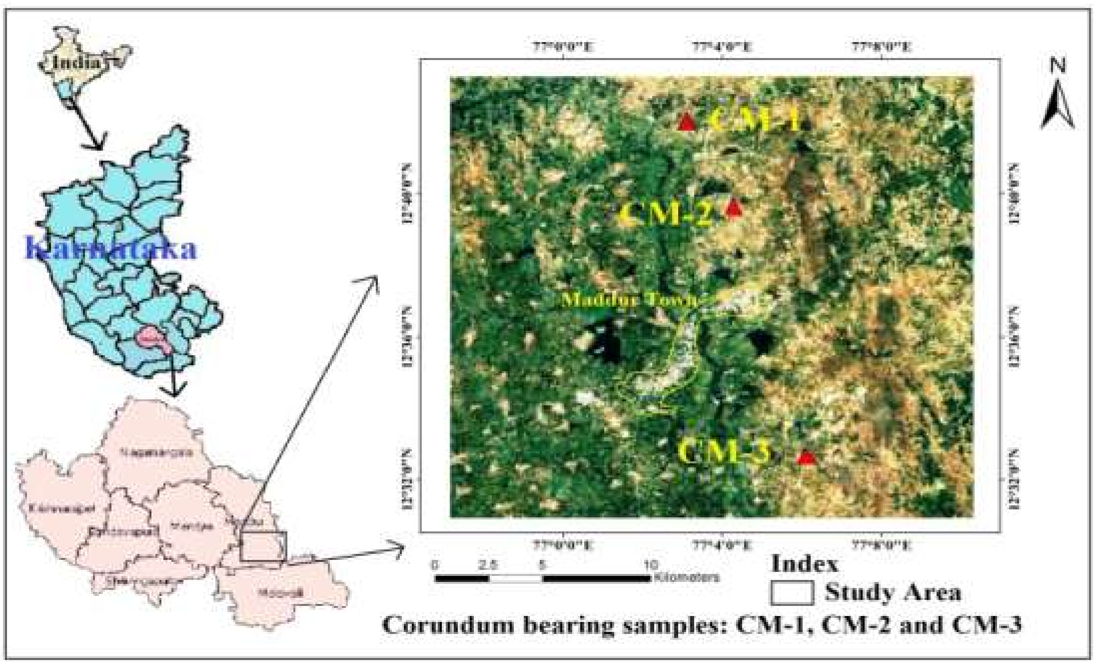

Fig.1. Google Earth image showing the location of the study area.

3. GEOLOGY:

The major rock types of the study area belong to Archaean era. They have been subjected to deformation and have undergone metamorphism. They have varied chemical compositions and are most complex and aptly designated as Archaean complex and consist of a wide variety of granite, gneisses and schist with associated quartzite and limestone (Ramakrishnan and Vaidyanadhan., 2008). The district for the most part, is made up of gneisses which are generally gray in colour with well developed gneissosity. Such rock structures are seen predominantly near Chinkuruli, but gneisses exposed near Melkote, Siddaghatta and other places are varied and complex (Radhakrishna, 1983). The Dharwar schists occur as narrow linear bands in many parts of the district. They are seen prominently between Bellibetta, Hadanur, Krishnarajpet and Chinakurali. The Bellibetta band extends southwards for about 25 km from a point six kilometres west of Krishnarajpet, near Bellibetta up to the river Cauvery (Naqvi and Rogers, 1983; Radhakrishna and Naqvi, 1986). Hadanur band is a separate band forming part of Krishnarajpet schist belt and not the extension of Nuggehalli belt Another band extends from Yediyur to Karighatta with dark hornblende schist as its main component. Banded iron formations with lenses of quartz is exposed between Maddur and Channapattana (Swaminath and Ramakrishnan, 1981). The study area mainly occupying the rock type's granitoid gneiss, ultramafics, Banded Magnetite Quartzite (BMQ) and basic dyke, these rocks are of great economic importance because of the presence of corundum. Important deposits are reported from Satanur near Mandya, Erehalli, Kirangur and Ramanahalli areas (Ramakrishnan and Vaidyanadhan., 2008).

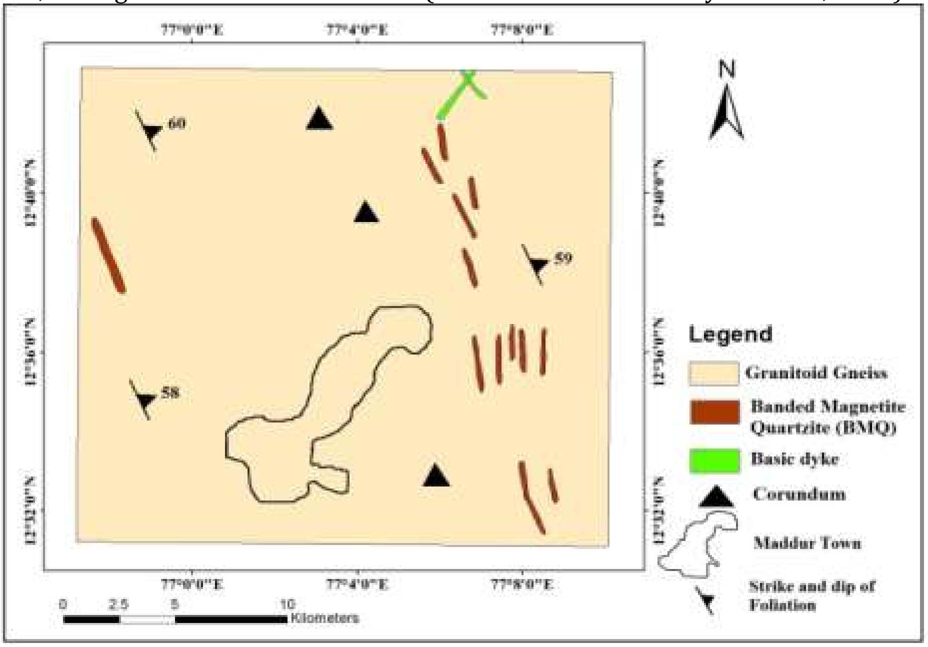

Fig.2. Geological map of the study area with sample Locations (after GSI 1965)

4. Geomorphology

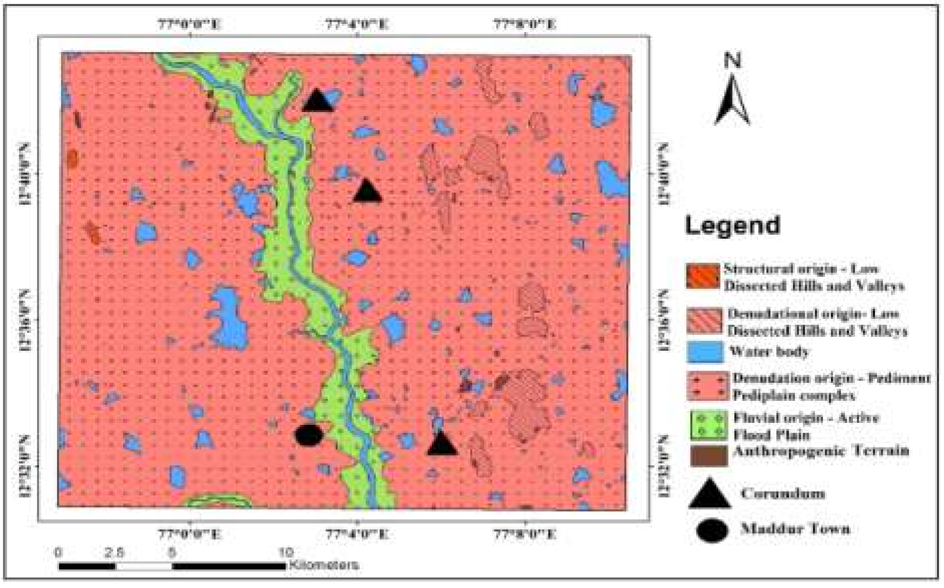

Fig.3. Geomorphological map of the study area with sample Locations.

Geomorphologically, a major part of the district is covered with the denudational uplands on gneisses and granites which are ideal for agriculture, industrialization and urban settlements, given suitable inputs. Besides there are structural ridges of the schistose rocks are suitable for mining of manganese, dolomite and limestone deposits (Ramakrishnan and Vaidyanadhan., 2008). The surface topography is in the form of undulating plain situated at an average elevation of 750-900m above msl. There are few sporadic out crops of rocks as hills and few fertile shallow valleys. The Cauvery river breaks through the several hill ranges and forms the famous Gaganachukki and Barachukki water falls (Swaminath and Ramakrishnan, 1981). The Melukote range of hills fallen a broken series of conspicuous peaks, which reach the altitude of 1159m above msl, 1064m above msl, 1050m above msl and 1046m above msl. The Hulikere-Karigatta hill range near Srirangapatana and rugged with low peaks near Sindhugatta are also conspicuous. The general slope in the district is in southeast direction (Radhakrishna, 1983). The Study area is occupied by red sandy soil, red loamy soil along the eastern part mixed red and black soils and this area also thin gravelly and underlain with a murrum zone containing weathered rock. The soils are highly leached and poor in bases the water holding capacity is low. (CGWB, 2012).

5. METHODOLOGY

Field based samples were collected and carried carefully to the laboratory for Petrographic study using Petrological, Mineralogical research Microscope; while geochemical data was received through XRF, Materials Science & Technology Division NIIST Thiruvananthapuram, Kerala. Hyperspectral signatures analyses for all samples were carried out using Lab Spectro-radiometer instrument (Spectral Evolution SR-3500) at Department of Earth Science University of Mysore, Manasagangothri, Mysuru. (Basavarajappa and Maruthi., 2018). 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 well correlated with the standard curves of USGS, JPL and JHU. Survey of India (GSI) topo map and Geological quadrangle map (57h and 57d) of 1:2.50.000 scale is used during the field work to study corundum bearing litho units. Bhuvan Indian Geo – Platform of ISRO thematic services used during Geomorphology map. Garmin-12 GPS is used to record the exact locations of each sample with an error of 9 mts during field visits (Basavarajappa et al., 2017).

6. PETROGRAPHY

6.1 Corundum: The corundum optical properties show Color: colorless, pink to blood-red colored The red color is caused by the mineral chromium and shows brownish tone due to the presence of iron. Relief shows high to very high. Prismatic, tabular or skeletal crystals and Rhombohedral parting cleavages are common. pleochroism is very strong in ordinary light and shows deep red color when viewed in the direction of vertical axis and a much lighter color to nearly colorless in view at right angles to this axis. Birefringence weak, Uniaxial negative. but often up to low II order due to extra thickness of ultra-hard corundum. Parallel extinction. (Fig.4).

Sericite optical properties shows Color: Brown or turbid pale greyish, Monoclinic system, anisotropic, Pleochrosim – nill Relief weeak, Cleavage very good in one direction in basal sections have no cleavage, Biaxial high birefringence sericite also fills the micro fractures in plagioclase, but it does it in elongated crystals, unlike the rather equant hematite crystals. Sericite is a fine-grained variety of muscovite, with the same composition $KAl_2(AlSi_3O_{10})(OH)_2$. It usually forms by hydrothermal alteration of K-feldspars, which provide the necessary potassium (Basavarajappa and Maruthi., 2018). It grows in pre-existing microfractures where the fluids can penetrate, or in fractures created by the fluid pressure., sericite fills cracks around and across plagioclase crystals, sericite that probably has replaced feldspar (Maruthi et al., 2018) (Fig.4).

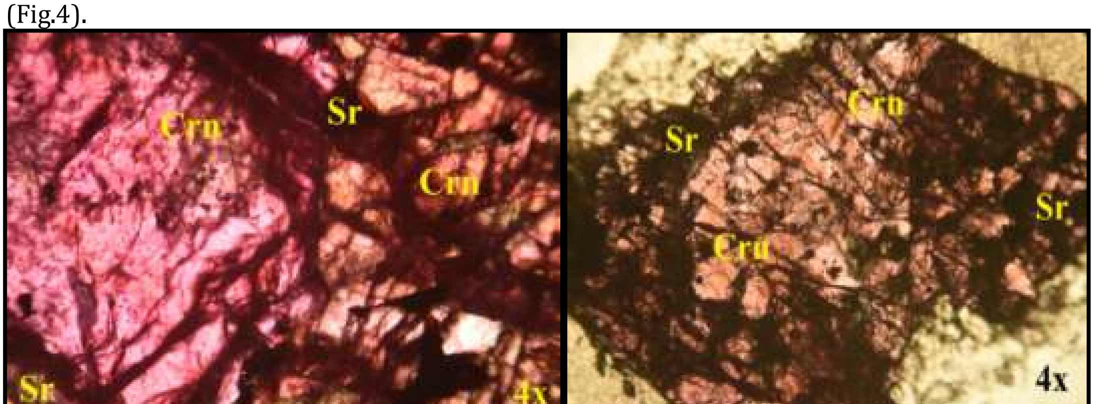

Fig.4. Microphotographs of Corundum.

7. HYPERSPECTRAL SIGNATURS

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). 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 (Photodiode Array) covering the visible range and part of the near infrared (up to 1000nm) and two 256-element InGaAs 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.

8. RESULT AND DISCUSSION

Major element composition of samples of corundum bearing rocks were determined at the chemical division and geochemistry its using XRF method. Corundum bearing rocks were determined at the using spectral signatures. The spectrometer component is a crossed Czerny-Turner configuration using ruled gratings as the dispersive elements. Energy enters the spectrometer and is collimated before being reflected off the gratings and refocused onto the PDA (Photodiode Array) detectors. There are three detectors. The first is a 512-element silicon array covering the spectral range from 350 to 1000 nm (280–1000nm). Two thermoelectrically cooled InGaAs (Indium Gallium Arsenide) arrays of 256 elements each extend the spectral range up to 1900nm and 2500nm respectively. The spectroradiometer and controlling electronics are contained in the housing. International standards for minerals such as USGS were compared along with the major elements for the field samples to check precision and accuracy of measurement. The certified and analyzed values of USGS are given in the fig.5 along with major element abundances of samples to check the error limits of measurement (Hunt et al., 1971).

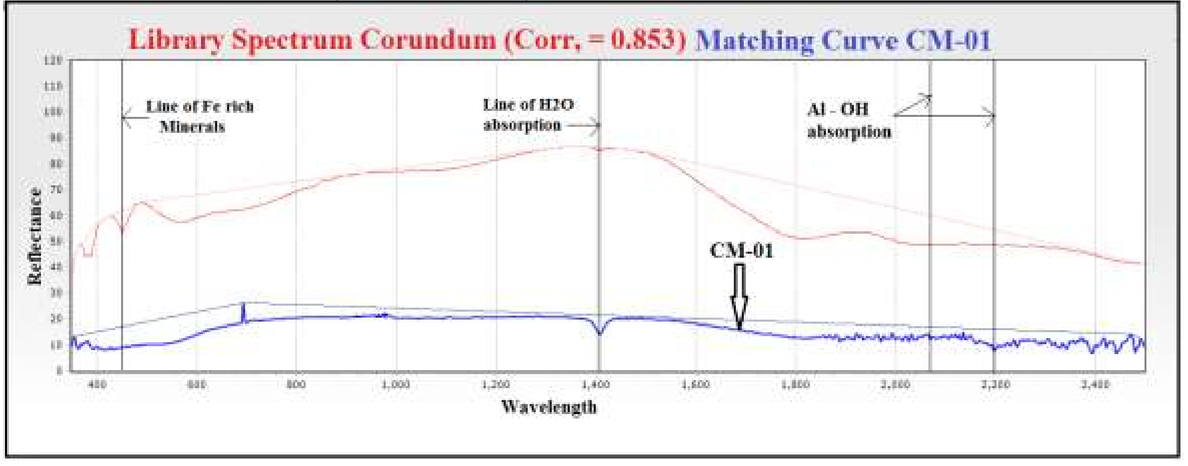

Fig.5. Lab Spectral signatures of Corundum, Maddur area.

Hyperspectral signatures determined the graph showing alumina oxide, Fe and H_2O presence in the sample. Corundum Al_2O_3 mineral type - Oxide this sample prepared from crystals that were brownish near the surface and bluish – green near in the interior. Very sharp corundum reflections suggest excellent crystallinity and compostional homogeneity (Maruthi et al., 2018). composition discussion analysis showed the sample to contain 0.2 and 0.27% Cr. 1.57% Fe and 10.01% Si with traces of Ti, V, Mn, Mg, Ca and Cu the iron appears to be present on both ferrous (0.55. 0.45 and 1.1um absorption features) and ferric (0.7. 0.45 and near 0.4um) from the Cr^{3+} ion contributes to the 0.4. 0.55 and 0.7um (emission) features. Spectral discussion Sample plots are correlated with standard USGS Spectral Library using absolute reflectance v/s wavelength which provide strong absorption range in 2.20 μm and 0.65 μm representing the mineral corundum shows intense absorption feature in 2.40 μm of the electromagnetic spectrum (Hunt et al., 1971). Absorption anomalies at wavelength regions of 0.55 μm and 0.9 μm of Fe3+ and Fe2+ ions are observed respectively with low reflectance in the VNIR region (Ali M. Qaid et al., 2009) (Fig.5). Major element content as Al_2O_3 content shows high range imparts a corundum character with that of high aluminum content. Library spectrum corundum correlation score 0.853 percent match the curve (Fig-5)

Table.2. Major and Minor Elements with Spectral analysis data of the study area.

Chemical Elements		**Samples**		
		CM-1	**CM-2**	**CM-3**
Elements (wt%)	SiO_2	10.1	10.2	8.56
	Al_2O_3	***84.12***	***83.92***	***85.63***
	Fe_2O_3	1.57	1.23	1.08
	CaO	1.09	1.27	1.4
	MgO	NIL	NIL	NIL
	K_2O	0.19	0.21	0.22
	Cr_2O_3	0.23	0.2	0.27
	TiO_2	1.01	1.7	1.6
	MnO	0.032	0.083	0.084
	P_2O_5	0.75	0.71	0.74
	Total	**99.092**	**99.523**	**99.584**
Rock type		Corundum	Corundum	Corundum
Spectral Analysis				
Absorption spectra (μm)	Lab spectral signature	2.10, 2.20, 2.40 0.65	2.10, 2.20, 2.40 0.65	2.10, 2.20, 2.40 0.65
Best matches to	USGS	Corundum	Corundum	corundum

9. CONCLUSION

Hyperspecral signatures, optical properties, XRF analysis, Arc GIS and Epsilon3 Omnian software's helps to find out Geological, Petrographic, Physical and Chemical characteristics and discrimination shows purity of the mineral present in the Precambrian rock. Analyzed and Studies for the selected samples were carried out and identified mineral assemblage of corundum bearing rocks. The perfect tabular texture and pink to red, pale blue pleochroic character reveal the presence of corundum mineral present in the collected samples. Lab spectra of corundum identified in the wavelength of 2.10 μm and 2.20 μm regions through the absorption curve matches the USGS standard shows the purity of mineral present in the rock. Hyperspectral signature data were analyzed for the same part of corundum bearing sample using Lab Spectro-radiometer which shows best match with that of USGS Spectral Library Standards. Corundum purity of corundum mineral is best curve matches to compare the Spectral Evolution (SR-3500) instrument.

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