



PHYSICAL AND OPTICAL PROPERTIES OF AQUAMARINE GEMSTONE- A CASE STUDY FROM VEMIREDDIPALLE AREA, KRISHNA DISTRICT, ANDHRA PRADESH, INDIA

Nazia Sultana¹, P Raghuram² and Sankara Pitchaiah Podila³

¹Department of Geology, Acharya Nagarjuna University, Andhra Pradesh, India

²Department of Civil Engineering, S.R.K.R. Engineering College (A), Bhimavaram

³Department Geology, Acharya Nagarjuna University, Andhra Pradesh, India

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ABSTRACT

A gemstone is a mineral or an organic substance, which looks attractive when fashioned into an ornamental object such as a bead, carving, box, cabochon or faceted stone. In India Aquamarine was reported from Andhra Pradesh, Odisha, Rajasthan, Kerala and Karnataka. The author reported the occurrence of Aquamarine from Vemireddipalle area, Krishna District, Andhra Pradesh, India, for the first time. Physical (colour, hardness and specific gravity) and Optical (refractive index, optic sign, birefringence, pleochroism, Fluorescence, luster and transparency) properties are studied using standard gemological methods. The study concluded that the physical and optical properties are consistent with Aquamarine gemstone.

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INTRODUCTION

There are over 4000 known mineral species. However, very few of these are gemstones. A gemstone can be defined as a mineral, or in the case of coral or pearl, an organic substance, which looks attractive when fashioned into an ornamental object such as a bead, carving, box, cabochon or faceted stone (Singh, 2014).

Natural gemstones are minerals or organic matters that are used in jewelry after cutting and polishing them (<https://www.petrageoms.com>). There are nine important natural gemstones which were widely popularized among the public as Navratnas. The growth of this science has been prompted and propelled in the recent years by the increasing number and sophistication of laboratory-grown (Synthetic gemstones) and of the applied treatments and enhancements to natural gemstones (Shah, 2012). A gemstone's value is based on its beauty, rarity, durability and history behind that particular stone (Singh, 2014).

Distribution in India

In Andhra Pradesh, Nazia sultana and Sankara Pitchaiah (2018) reported Aquamarine occurrence from Putrela, Krishna District. In Odisha, Aquamarines are reported from Banjipadar-Sargiguda sector, Ghuchepara-Antarla sector and Ghumsar –Delhi belt and Suklimuri sector in Bolangir district.

**Corresponding author: Nazia Sultana*

Department of Geology, Acharya Nagarjuna University, Andhra Pradesh, India

Sea blue aquamarine from Sonepur district, Charbali-Beldihi near Rairakhora, Bagdhapa –Tablai and Meghal-Ranchipada areas in Sambalpur district (Geology and Mineral resources of Odisha, 2012). Aquamarine reported from Rajasthan, Toda raising and Hanotia in the Tonk district, Ajmer and Bhilwara districts (Geology and Mineral resources of Rajasthan, 2011) and Aravalli region. Industrial beryls are found in the mica mines of Gudur - Nellore in Andhra Pradesh and Hazaribagh and Monghyr districts of Bihar. The famous Sunjam sapphire mines in Kashmir have yielded several fine crystals of Aquamarine along with the world famous sapphires. Greenish blue Aquamarine has been reported from Ooruttamalam and Uzhamalakkal in Kerala. In Karnataka, Aquamarine was recovered from Melukote in Hassan district (in Mathew, 1998).

The present study is concentrated on Physical and Optical properties of Aquamarine gemstone from Vemireddipalle area of Krishna District, Andhra Pradesh, India (Figure 1).

METHODOLOGY

Location map is prepared using Survey of India (SOI) topographical maps on 1:50,000 scale. All the streams, streamlets and canals shown in the toposheets are delineated for the preparation of drainage network map. Drainage map is extracted from toposheets of Survey of India (SOI) 65C12, and 65 C16 (12 sheets) on 1:50,000 scale.

The physical and optical properties, i.e., colour, hardness, specific gravity, refractive index, birefringence, optic sign,

pleochroism, Fluorescence, luster and transparency are examined using Standard methods. For this, 25 samples are collected from the pediment zones of hilly terrains.

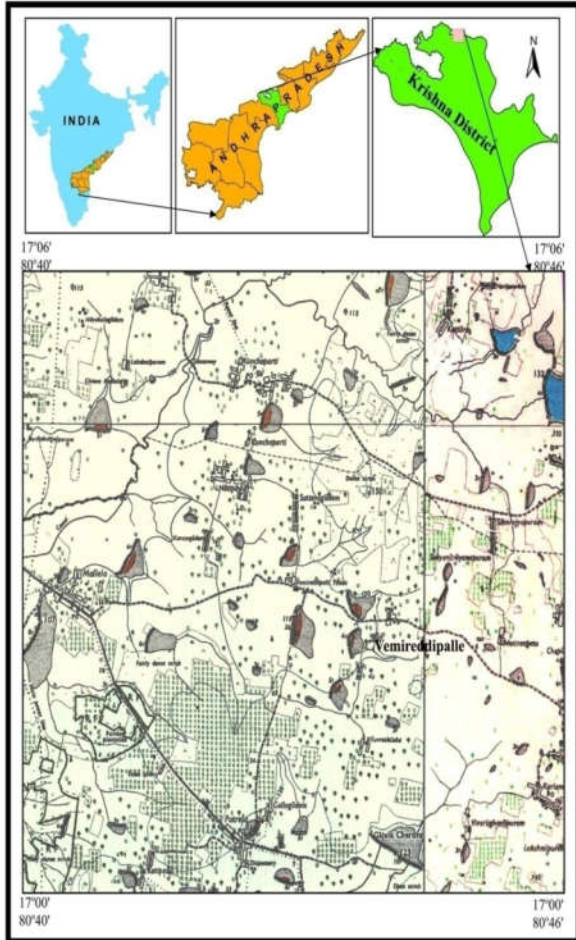


Figure 1 -Location of Vemireddipalle area-Survey of India Toposheet

Colour grading chart is used to assess the colour. Hardness is measured using a Mohs Hardness scale. The Specific gravity is estimated using Hydrostatic method.

Refractive index, Optic sign and Birefringence are measured using Refractometer. Using a Polariscop it is assessed whether the mineral is single/double refractive. Pleochroism and Fluorescence are studied using Dichroscope and Ultra Violet light respectively.

RESULTS AND DISCUSSION

In this section, details of Drainage and Water Resources, Physical and Optical properties are presented.

Drainage and Water Resources

Yedula vagu is the main stream flowing in the northern and eastern parts of the study area. Nagarjuna Sagar left canal passing from North to South. In the area, number of canals and tanks are distributed (Figure 2).

Physical Properties

Colour, Hardness and Specific Gravity are studied under Physical properties. The observations are given in table 1.

Colour

Colour is an important property to identify a gemstone. It results from the way gemstones absorb light. When white visible light passes through a gemstone some of the energy is reflected and some of the energy of the white light is absorbed in gemstone which caused colour in gemstone (<http://shodhganga.inflibnet.ac.in>). It influences the value of gemstones. The most common cause of colour in gemstones is the presence of small amount of transition metal ions. These transition metal ions have an incomplete set of 3d electrons. Changes in the energy of these electrons correspond to the energy of visible light. The light that is transmitted or reflected appears coloured, because those colours corresponding to 3d electron energy transitions have been absorbed (<http://scifun.chem.wisc.edu>). The Aquamarine samples are light to dark greenish blue in colour. Here, the colour caused due to presence of Iron and Cr.

Hardness

Hardness is the resistance to scratching of a smooth surface (<https://www.wikigempedia.com>). Talc has the lowest hardness (1) and the Diamond has the highest (10). The hardness <7 is less preference in the case of gemstone. If the hardness is above 7 it takes better polish and display great luster. It is an important consideration, when designing and wearing jewelry. As, overall wearability grade hardness takes into an account. The samples in the present study show that 7.5-8.0 hardness and take a good polish and show a great luster.

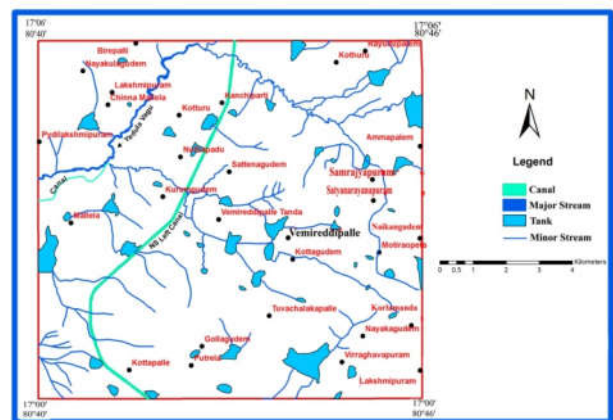


Figure 2 Drainage and Water Resources Map of Vemireddipalle Area

Specific gravity

Specific gravity is a way to express the relative density of a gemstone. It is observed that the Specific gravity varies in between 2.66 and 2.70 for the Aquamarine samples.

Optical Properties

Refractive index, Optic sign, Birefringence, Pleochroism, Fluorescence, Lustre and Transparency are observed (Table 1) and are explained.

Refractive index

The ratio between the optical density of the gemstone and that of air is known as Refractive Index (RI) of a gem (Read, 1983). Gems with a higher RI tend to show more brilliance. It is observed that the RI of the Aquamarine samples varies in between 1.570-1.582, which are medium.

Optic Sign

The Optic axis of a gemstone (Uniaxial or Biaxial) and optic sign (Positive or negative) can also be determined using a refractometer. The Aquamarine samples are Uniaxial with a negative sign and Double refractive.

Fluorescence

The emission of light from within a substance while it is being exposed to direct radiation, or in certain cases to an electrical discharge in a vacuum tube, is known as fluorescence (Dana and Ford, 1922). Inert to weak Fluorescence is observed in the samples.

Table 1 Physical and Optical Properties of Aquamarine

Sample No	Colour	Hardness	Specific Gravity	Refractive index	Optic axis and Sign	SR/DR	Birefringence	Pleochroism	Fluorescence	Lustre	Diaphaneity
1.	Medium greenish blue	7.5-8	2.68	1.575-1.582	U-Ve	DR	0.007	Dichroic	Inert to weak	Vit.	TP
2.	Dark greenish Blue	7.5-8	2.66	1.573-1.581	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TL
3.	Light greenish blue	7.5-8	2.68	1.571-1.580	U-Ve	DR	0.009	Dichroic	Inert to weak	Vit.	ST
4.	Light Blue	7.5-8	2.70	1.570-1.578	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	STL
5.	Greenish blue	7.5-8	2.70	1.572-1.580	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	STL
6.	Light greenish blue	7.5-8	2.69	1.574-1.581	U-Ve	DR	0.007	Dichroic	Inert to weak	Vit.	STL
7.	Medium greenish blue	7.5-8	2.69	1.571-1.578	U-Ve	DR	0.007	Dichroic	Inert to weak	Vit.	STL
8.	Light greenish blue	7.5-8	2.69	1.572-1.579	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
9.	Pale Blue	7.5-8	2.67	1.575-1.83	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
10.	Medium greenish blue	7.5-8	2.67	1.572-1.580	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP
11.	Light greenish blue	7.5-8	2.66	1.570-1.578	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP
12.	Dark greenish Blue	7.5-8	2.70	1.573-1.581	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP
13.	Light Blue	7.5-8	2.69	1.571-1.580	U-Ve	DR	0.009	Dichroic	Inert to weak	Vit.	TP
14.	Light greenish blue	7.5-8	2.68	1.573-1.581	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
15.	Pale Blue	7.5-8	2.68	1.570-1.578	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
16.	Light greenish blue	7.5-8	2.68	1.572-1.580	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
17.	Light Blue	7.5-8	2.68	1.571-1.579	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP
18.	Light greenish blue	7.5-8	2.70	1.570-1.578	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
19.	Dark greenish Blue	7.5-8	2.71	1.573-1.581	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
20.	Medium greenish blue	7.5-8	2.67	1.572-1.580	U-Ve	DR	0.008+-0.001	Dichroic	Inert to weak	Vit.	TP
21.	Medium greenish blue	7.5-8	2.67	1.573-1.580	U-Ve	DR	0.007	Dichroic	Inert to weak	Vit.	ST
22.	Light greenish blue	7.5-8	2.66	1.572-1.580	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	ST
23.	Light Blue	7.5-8	2.69	1.571-1.580	U-Ve	DR	0.009	Dichroic	Inert to weak	Vit.	TP
24.	Medium greenish blue	7.5-8	2.66	1.570-1.578	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP
25.	Light Blue	7.5-8	2.66	1.572-1.580	U-Ve	DR	0.008	Dichroic	Inert to weak	Vit.	TP

U-Ve-Uniaxial Negative; SR-Single Refractive; DR- Double Refractive; TP-Transparent, TL-Translucent, ST- Semi Transparent; STL-Semi Translucent; Vit. Vitreous

Birefringence

The birefringence, or amount of double refraction, varies with different minerals. It is expressed numerically by a figure that is the difference between the greatest and least indices of refraction of a given mineral (Dana and Ford, 1922). It ranges from a low of 0.003 to a high of 0.287 (<http://www.bwsmigel.info>). The high birefringence of gemstones can add a velvety appearance to the gemstones, which softens the color in a way, might find very appealing (<https://www.ganoksin.com>).

The samples show 0.007 to 0.009 birefringence. This medium birefringence supports that this mineral has medium appealing look.

Pleochroism

This is the generic name given to the optical quality, which some stones possess, of splitting the light passing through them into two or three different shades or colours (called dichroism and trichroism respectively) (Read, 1983). The strength of pleochroism in a stone that displays the phenomenon is related to the depth of color of the stone; i.e., a colorless stone displays none, whereas a very dark-colored stone displays it to a maximum degree (<http://www.gemstones-guide.com>).

The Aquamarine samples show Dichroism, which indicate medium depth of colour.

Lustre and transparency are also observed in the samples and found that they have vitreous lustre and transparent to semi translucent look.

CONCLUSION

Aquamarine is a variety of beryl gemstone. Physical and optical properties are studied using standard gemological methods. The samples are light to dark greenish blue in colour. They show Vitreous luster and are Transparent to Translucent. Crystal is Uniaxial negative, Double refractive and exhibit Inert to weak fluorescence. Hardness of the samples is high, Specific gravity is medium and the Birefringence values are intermediate. Based on the Physical and Optical properties, the samples collected from Vemireddipalle area are confirmed as Aquamarine gemstone.

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