PHYSICAL AND OPTICAL PROPERTIES OF CHALCEDONY GEMSTONE- A CASE STUDY FROM KOLLURU AREA, GUNTUR DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT

A gemstone is a mineral and in cut and polished form, is used to make jewellery or other adornments. Chalcedony is one of the important quartz mineral variety. Characteristically, it is a cryptocrystalline type of quartz. In India, Chalcedony was reported only from Maharashtra. The authors reported the occurrence of Chalcedony for the first time from Kolluru area of Guntur district, Andhra Pradesh, India. Physical and Optical properties are studied to identify the gemstone using Standard methods. The study found that the properties are consistent with Chalcedony.

KEYWORDS

Chalcedony, hardness, refractive index, pleochroism, fluorescence.

I. INTRODUCTION

A gemstone is a piece of mineral crystal which, in cut and polished form, is used to make jewellery or other adornments (The Oxford Dictionary, 2007 and Nancy, 2009). Since ancient times mankind has a fascination towards gemstones. Among the available gemstones, a large amount of them possesses one or more of the appealing qualities such as colour, Luster, transparency, brilliance, fire, etc., (Yusuf, 2008).

Among the quartz varieties, Chalcedony is one of the important mineral. Characteristically, it is a cryptocrystalline type. The gemstone is compact to a dense, which means extremely fine crystallization (https://www.gemselect.com/english/ gem-info/).

Kingma and Hemley (1994) identified the samples of microcrystalline silica with Raman spectroscopy. The study concluded that the moganite in samples of Chalcedony, chert, and flint obtained the pure phase a strong band is found at 501 cm, which may be correlated with the four-membered rings of SiO, tetrahedral in the refined structure.

In Chalcedony, Moganite varies between 1% and 20%. Aging slowly converts the moganite into quartz and results in moganite-free Chalcedony. It contains small amounts of water (1-2%), both as molecular water and bound in silanole (Si-OH) groups (in https://www.mindat.org/min-960.html).

Heaney and Post (1992) showed that Chalcedony is a mixture of quartz and moganite. Powder x-ray diffraction patterns produced by fibrous quartz (agate, Chalcedony) and nonfibrous quartz (chert, flint) indicated that the concentrations of moganite within each subgroup are widely distributed. The results indicated that moganite is so prevalent in unaltered specimens that its absence in microcrystalline quartz varieties may be useful as an indicator of fluid-rock interactions.

Uses of Chalcedony

- Chalcedony has been used as gemstones and other ornamental objects for thousands of years.
- Some of the earliest primitive stone tools (axes) fashioned by man's ancestors 2.5 million years ago in the Omo valley in Ethiopia, were made of quartz varieties such as agate, chert and Chalcedony. These materials were used because of their hardness and their isotropic brittleness, which made it possible to shape the tools with relative ease (https://www.mineralminers.com/).

Distribution

The Chalcedony deposits are reported from India, Brazil, China, France, Germany, Italy, Malawi, Mexico, Morocco, Namibia and the USA.

Country-wise details are given below (http://www.quartzpage.de/chalcedony).

India	-	Aurangabad, Nasik in Maharashtra
Brazil	-	Irai, Rio Grande Do Sul,
France	-	Departement Charente, Poitou-Charentes
Germany	-	Offenstetten near Abensberg, Bavaria
Italy	-	Ploaghe, east of Sassari and Masulas in Sardegna

Malawi - Chikwawa District
Mexico - Aguascalientes
Morocco - Sidi Rahhal, El Kelaâ des Sraghna
Namibia - Southern Namibia; south-west of Karasburg and near Outjo, Damaraland District. Collection Jacek Szczerba
USA - Juab County and Utah; Turtle Mountains in Southern California; Mopah Peak area in Southern California; south of Thumb Peak in the Mule Mountains, California; the Opal Hill Mine, Palo Verde, California; Colorado river at Grand Canyon, Arizona; World News on Mineral Occurrences (1961) reported the occurrence of Chalcedony in Illinois, Midwestern and Great Lakes regions of the United States and from Hay Springs (Sheridan Co.), Nebraska.

The present study is concentrated on Properties of Chalcedony from the Kolluru area of Guntur district, Andhra Pradesh, India.

II. ABOUT THE STUDY AREA

The Guntur district is famous for various gemstones, i.e., Diamonds, Rock crystal and Chalcedony. The present research area, Kolluru is a part of Guntur district, Andhra Pradesh. It is 50 km away from Guntur, Headquarters of Guntur district and 47 km from Vijayawada a famous town in Krishna District. The location of the area is shown in figure 1.

Tropical climate conditions with extreme hot summer and cold winter prevail in the Guntur District. Annual average minimum and maximum temperatures of the district ranges from 17.3°c to 27.8°c and 30.6°c to 48.5°c respectively. The average annual rainfall of the district is 889.1 mm (CGWB, 2013).

The predominant crops such as paddy, jowar, bajra among cereals, tobacco, cotton and chillies among commercial crops and blackgram and red gram among pulses are the primary agricultural products cultivated in the district (District Survey Report, 2018).

III. METHODOLOGY

Area map is prepared using 1:50000 Survey of India toposheet (SOI) E44U2. Illegal collection of gemstones is a common phenomenon in Kolluru area. Twenty three Chalcedony samples are collected from Kolluru. All the samples are examined for physical and optical properties.

The properties studied are Hardness, Specific Gravity, Colour, Luster, Diaphaneity, Refractive index, Optic sign, Birefringence, Pleochroism and Fluorescence. Hardness is measured using a Mohs Hardness scale. Specific gravity is estimated using the Hydrostatic method. Colour grading chart is used to assess the colour. Refractive index measured using Refractometer. Fluorescence is studied using Ultra Violet light, respectively.

IV. RESULTS AND DISCUSSION

Physical and Optical Properties of Gemstone

Though there are many mineral physical and optical properties. The observations are shown in table 1.

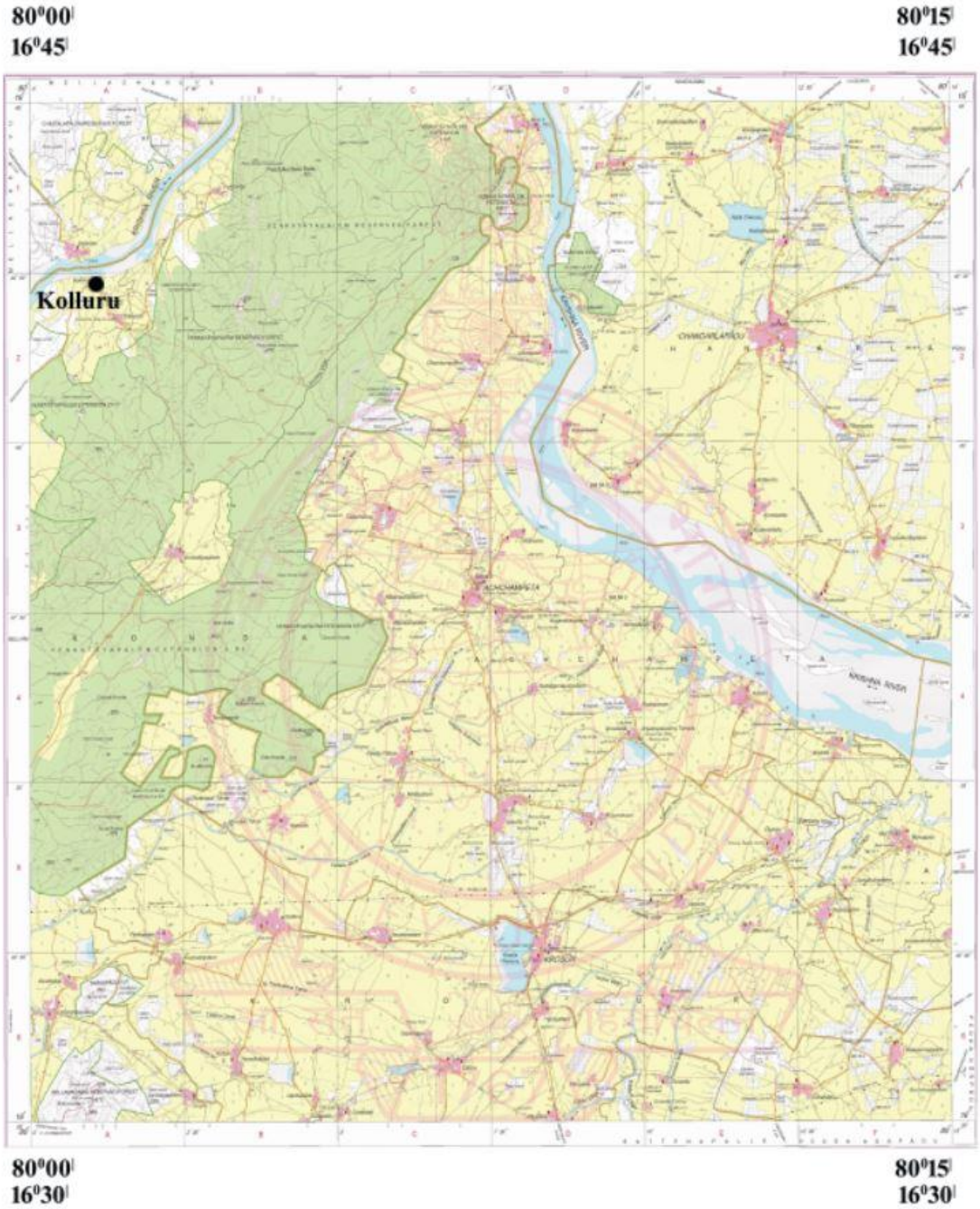

Fig. 1 Kolluru area (Survey of India Toposheet No. E44U2)

Table 5.10 Physical and Optical Properties of Chalcedony from Kolluru

S.No	Colour	Hard-ness	Specific Gravity	Refractive index	Optic axis and Sign	SR /DR	Birefring ence	Pleoch-roism	Fluore-scence	Lustre	Diapha-neity
1.	Pale Brown	6.5-7	2.59	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
2.	Pale Brown	6.5-7	2.58	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
3.	Pale Brown	6.5-7	2.60	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ
4.	Pale Brown	6.5-7	2.60	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
5.	Pale Brown	6.5-7	2.59	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
6.	White with bands	6.5-7	2.59	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
7.	White with bands	6.5-7	2.61	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
8.	White with bands	6.5-7	2.61	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	TL
9.	White with bands	6.5-7	2.62	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
10.	White with bands	6.5-7	2.59	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
11.	Light brown with spots	6.5-7	2.59	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
12.	Light brown with spots	6.5-7	2.59	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
13.	Light brown with spots	6.5-7	2.59	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
14.	Light brown with spots	6.5-7	2.58	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
15.	Light brown with spots	6.5-7	2.58	1.534-1.538	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
16.	Light brown with spots	6.5-7	2.58	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
17.	Light brown with spots	6.5-7	2.61	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	STL
18.	Pale Yellow	6.5-7	2.60	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ

19.	Pale Yellow	6.5-7	2.58	1.535-1.539	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ
20.	Pale Yellow	6.5-7	2.59	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ
21.	Pale Yellow	6.5-7	2.59	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ
22.	Pale Yellow	6.5-7	2.60	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ
23.	Pale Yellow	6.5-7	2.61	1.536-1.540	U+ve	AGG	0.004	Weak	Inert	Dull to Waxy	OPQ

U +Ve- Uniaxial Positive; AGG-Aggregate; TL-Translucent; STL-Semi Translucent; OPQ - Opaque

Hardness

Gemstones with hardness less than 7 are less preferred. If the hardness is above 7, it takes a better polish and displays great Luster. It is an important consideration, when designing and wearing jewellery, as overall wearability grade hardness takes into account (Smigel, 2016).

Chalcedony samples show 6.5-7 hardness, which can take a good polish and show a good luster.

Specific gravity

Scientifically, specific gravity is defined as a ratio of the mass of a given material to the mass of an equal volume of water at 4 degrees centigrade. Most gemstone substances are two to four times denser than an equal volume of water (https://www.gemselect.com/). Specific gravity is a way to express the relative density of a gemstone.

It is observed that the specific gravity lies between 2.59 and 2.62.

Optical Properties

Under Optical properties, Colour, Refractive index, Luster, Diaphaneity and Fluorescence are observed in table 1.

Colour

Colour is an important property to identify a gemstone. It influences the value of gemstones. The most common cause of colour in gemstones is the presence of a 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).

Chalcedony samples show pale brown, white with Black bands, light brown with spots and pale yellow.

Refractive index

The ratio between the optical density of the gemstone and that of air is known as the Refractive Index (RI) of a gem (Read, 1983). Gems with a higher RI tend to show more brilliance.

The Refractive index is medium in all the Chalcedony samples. The value varies between 1.534-1.540.

Luster

Luster is the optical effect created by light reflecting from the surface of the stone and is directly related to the quality of the surface polish, which can be produced on a stone (Read, 1983).

All the samples exhibited a Waxy luster.

Diaphaneity

It is the degree to which a stone transmits light. Transparency, or its converse, opacity, can be described for identification. The transparency is also partly affected by colour, i.e., dark coloured stones are less transparent than light coloured ones. Another factor that will affect transparency is the presence of internal flaws and inclusions (Read, 1983). Transparent stone is valued more as a translucent or opaque stone. It mainly depends on the clarity of a substance. The transparent stones are also very high in price.

The samples are Translucent to Opaque in the present study.

Optic Sign

The Optic axis of a gemstone (Uniaxial or Biaxial) and optic sign (Positive or negative) can also be determined using a refractometer.

Single/Double refractive is one that is useful in gem identification and can be readily detected with an instrument called a polariscope. If there is one refractive index (RI), no birefringence and no pleochroism. In doubly refractive (DR) gems, the light which enters splits into two perpendicular polarized beams. Such gems have birefringence and may show pleochroism. All DR gems have either one (uniaxial) or two (biaxial) optic axis directions in which they will behave as SR (http://www.bwsmigel.info/).

The Chalcedony samples show the Uniaxial optic axis and a Positive optic sign. The samples are AGG (Aggregate).

Birefringence

Birefringence ranges from a low of 0.003 to a high of 0.287 (http://www.bwsmigel). The high birefringence of gemstones can add a velvety appearance to the gemstones, which softens the colour in a way, might find very appealing (https://www.ganoksin.com).

Medium birefringence is observed with the samples, i.e., 0.004.

Pleochroism

The strength of pleochroism in a stone that displays the phenomenon is related to the depth of colour of the stone; i.e., a colourless stone displays none, whereas a very dark-coloured stone displays it to a maximum degree (http://www.gemstones-guide.com).

Pleochroism is weak in Chalcedony samples.

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 Fluorescence is observed in the samples.

V. CONCLUSION

Twenty three mineral samples were collected from Kolluru area and their Physical and Optical Properties are studied to identify the mineral. It is found that the Chalcedony samples are pale brown, white with Black bands, light brown with spots and pale yellow colours and are Translucent to Opaque. The samples have Waxy Luster, 6.5-7 hardness, Specific gravity between 2.58 -2.61, Medium Refractive index (1.534-1.540) and Medium birefringence (0.004). The samples show Uniaxial optic axis and a Positive optic sign and Aggregate. Based on these properties, the samples are identified as Chalcedony.

Based on the physical and optical properties, four varieties of chalcedony are identified, i.e., Carnelian (pale brown), Agate (white with Black bands), Jasper (light brown with spots) and Plasma (pale yellow). Out of the total 23 samples, five are Carnelian, five are Agate, six are Jasper and seven are plasma varieties.

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