

# Study on Chalcedony Gemstone from Kolluru Area, Guntur District, Andhra Pradesh, India

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## ABSTRACT

*Twenty three mineral samples are collected from the Kolluru area, Guntur District, Andhra Pradesh, India, for their identification. Fifteen samples are subjected to chemical analyses to estimate the major oxides using WD-XRF and EPMA. The trace elements are measured using ICP-MS. Based on the physical and chemical properties, the samples are identified as Chalcedony gemstone. Using the colour, luster and predominance of SiO<sub>2</sub> composition, four varieties, i.e., Carnelian, Agate, Jasper and Plasma are differentiated.*

**Keywords:** Chalcedony gemstone, oxides, trace elements, crystal chemistry.

## 1. INTRODUCTION

Chalcedony is one of the important minerals among quartz varieties. Characteristically, it is a cryptocrystalline type. The gemstone is compact to a dense, which means extremely fine crystallization (<https://www.gemselect.com>). In India, its occurrence is reported from Aurangabad, Nasik in Maharashtra. Among the other countries, Brazil, China, France, Germany, Italy, Malawi, Mexico, Morocco, Namibia and the USA are notable for the production of the Chalcedony.

## 2. STUDY AREA

The Kolluru area in Guntur district, Andhra Pradesh, India lies between 16°36'00" and 16°46'15" N latitudes and 79°42'30" and 80°02'30"E longitudes (Figure 1). The village is 101 km away from Guntur town, headquarters of the Guntur district. The total area of the research is 49 sq.km. The Krishna River shows a sinuous course and forms the northern boundary. The satellite image of the area is shown in plate 1.

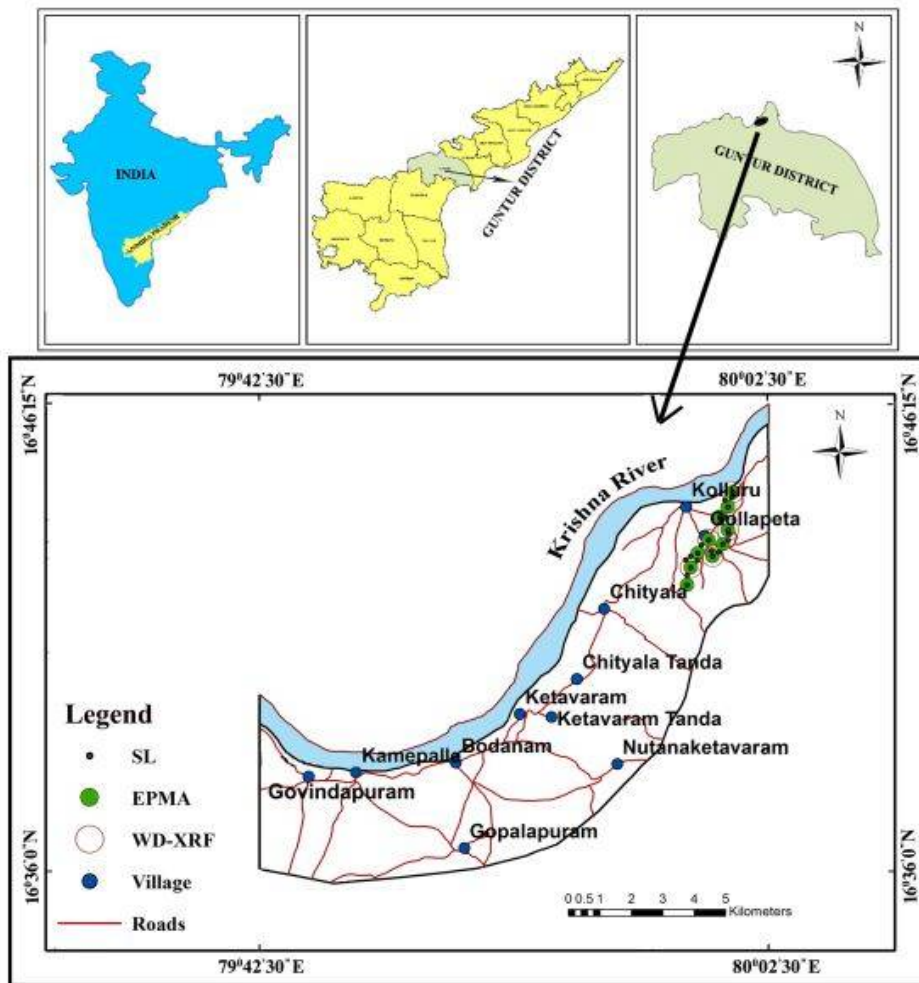


Figure 1 The Study area (SL –Sample locations)

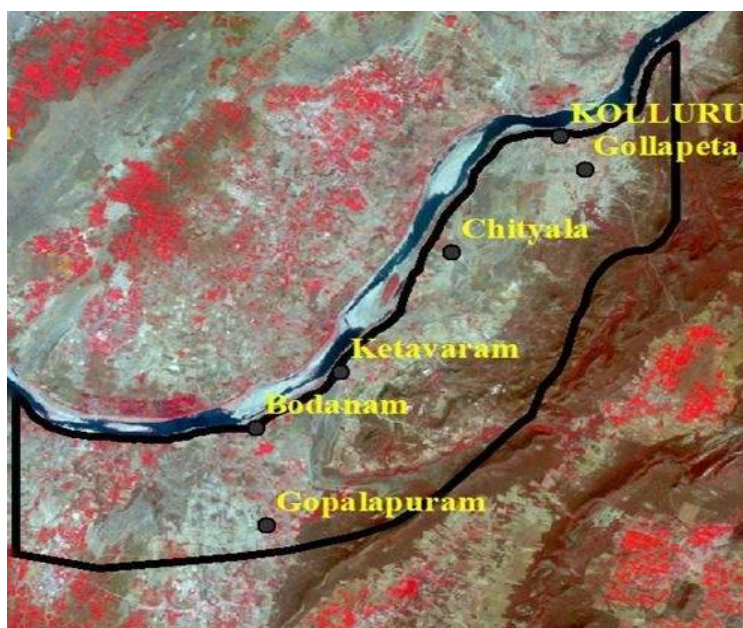


Plate 1 Satellite image of the Kolluru area (Source: Bhuvan Portal); Solid line indicates the area boundary

The Chalcedony is deposited in the pediment and alluvial soils in and around Kolluru (Plates 2 and 3). The rough samples collected from the study area are shown in plate 4.



**Plate 2** Chalcedony in Pediment zone



**Plate 3** Chalcedony in Alluvial soils



**a – Carnelian**

**b –Agate**



c – Jasper

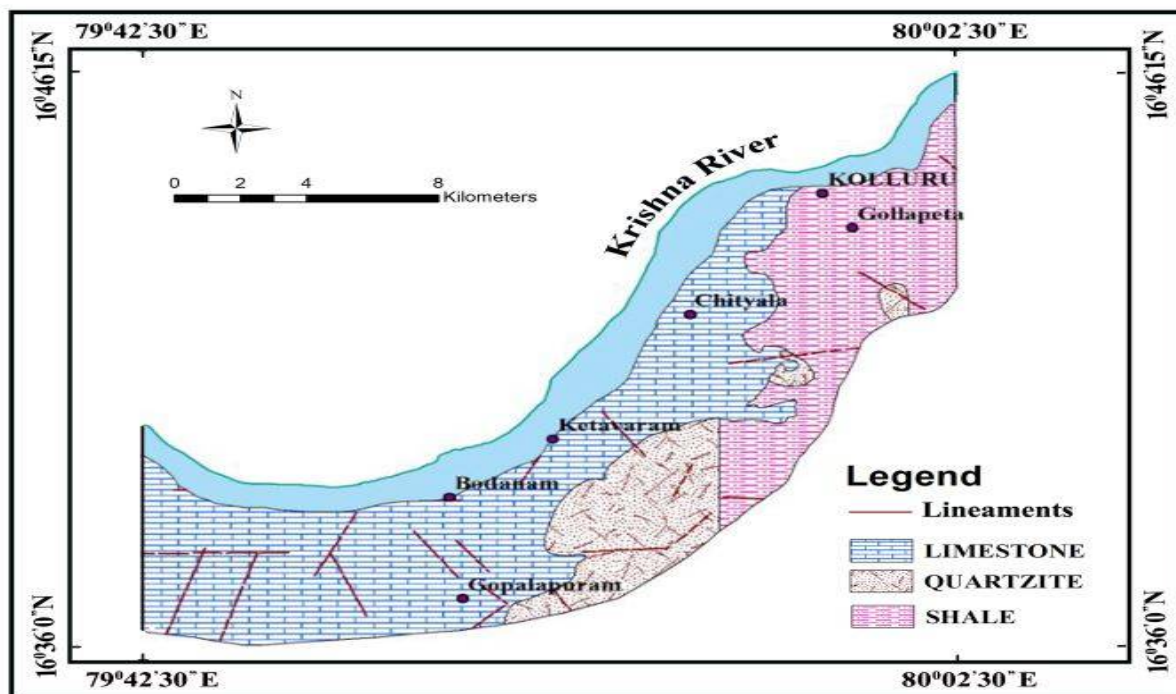
d- Plasma

**Plate 4** Chalcedony varieties from Kolluru area

### Geology of the area

Geology of the area is studied by King (1872) and Nayak (1993). The sediments of the area are reported by Rao (1982 – 83, 1983 – 84). The Nallamalai group of rocks belongs to the Cuddapah super group exposed in the area. The important rock types are Limestone, Quartzite and Shale. Among these rocks, limestone's occupied most of the area followed by Shale and Quartzite. The Geology of the area is shown in figure 2.

Limestones are predominant in and around Govindapuram, Kamepalle, Bodanam, Gopalapuram, Ketavaram, Ketavaram Tanda, Chityala Tanda and Chityala. Quartzite is present in and around NutanaKetavaram. Shales are observed in between Gollapeta and Kolluru. Some lineaments (inferred) are noticed in the area (Figure 2).



**Figure 2** Geology of Kolluru area

The main objective of the present study is to identify the samples collected in and around Kolluru and Chityala.

### 3. METHODOLOGY

The area maps, geology of the area are prepared using Survey of India (SOI) topographical maps on 1:50,000 scale, Bhuvan Portal and Landsat images, along with collateral information.

**Twenty three Chalcedony samples are collected from pediment zones and alluvial soils. Out of the total, 15 samples are selected for chemical analyses.**

For the estimation of oxides, Five samples were subjected to Electron Probe Micro Analysis (EPMA) and another five were Wavelength Dispersive X-ray Fluorescence (WD-XRF). The ICP-MS is also employed to analyze the trace elements. The analyses were carried out with the help of the Geological Survey of India (GSI) Laboratory, Hyderabad.

Fe<sub>2</sub>O<sub>3</sub> is calculated as per the formula given by Groat et al., (2010). H<sub>2</sub>O is calculated as per the formula given by Turner et al., (2007). The crystal chemistry is also studied by calculating the number of atoms present.

#### 4. RESULTS AND DISCUSSION

**Shahabudden and Nazia Sultana (2020) explained that the 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 2.59 and 2.62, Medium Refractive index (1.534-1.540) and Medium birefringence (0.004). The samples are AGG (Aggregate) and show Uniaxial optic axis and a Positive optic sign. Based on these properties only, 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).

##### 4.1 Chemical Composition

Fifteen samples are subjected to chemical analyses and estimated SiO<sub>2</sub>, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, MnO, MgO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub> and NiO and H<sub>2</sub>O (Table 1). SiO<sub>2</sub> ranges from 96.71 to 100, with an average quantity of 98.53wt%. Regarding the other oxides, Fe<sub>2</sub>O<sub>3</sub> lies between 0.01 and 1.06 (average, 0.31), H<sub>2</sub>O, 0.84 and 0.92 (average, 0.88), Al<sub>2</sub>O<sub>3</sub>, 0.00 to 0.16 (average, 0.06) and MgO, 0.01 to 0.12 (average, 0.01). TiO<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub>, MnO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, and NiO are present in small quantities.

##### 4.2 Trace Elements

The trace elements determined are Ba, Ga, Sc, V, Th, Pb, Ni, Co, Rb, Sr, Y, Zr, Nb, Cr, Cu, Zn, Be, Ge, As, Sn, La, Ce, Pr, Nd, Eu, Sm, Td, Gd, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta and U (Table 2). Among the trace metals, Cr is present in higher concentrations (85 to 109), followed by Ba (<50), Zn (<10 to 29), Cu (13 to 22), V (<20), Zr (17 to 19), Sr (9 to 12), Be (2.42 to 11.14), Th (5 to 8) and Pb (4 to 8). The remaining trace elements are noticed in minor concentration.

**Table 1 Chemical Analyses of Chalcedony Samples (wt%)**

Samples	Analyzed using WD-XRF					Analyzed using EPMA										Avg.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Oxides																
SiO <sub>2</sub>	96.71	96.83	97.53	97.19	97.53	100.58	99.40	99.19	98.83	98.91	98.98	98.75	99.13	99.45	98.99	98.53
TiO <sub>2</sub>	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01
Al <sub>2</sub> O <sub>3</sub>	0.16	0.15	0.14	0.12	0.14	0.00	0.02	0.00	0.01	0.02	0.00	0.03	0.03	0.02	0.01	0.06
Cr <sub>2</sub> O <sub>3</sub>	NA	NA	NA	NA	NA	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.03	0.00	0.00	0.00
<sup>a,b</sup> Total Fe as Fe <sub>2</sub> O <sub>3</sub>	0.90	0.79	0.92	0.73	1.06	0.00	0.01	0.02	0.00	0.04	0.02	0.01	0.09	0.00	0.06	0.31
MnO	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.01	0.07	0.00	0.01
MgO	0.12	<0.10	<0.10	<0.10	<0.10	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01
CaO	0.11	<0.10	0.10	<0.10	0.11	0.05	0.03	0.00	0.03	0.04	0.02	0.06	0.02	0.01	0.05	0.04
Na <sub>2</sub> O	<0.10	<0.10	<0.10	<0.10	<0.10	0.08	0.00	0.00	0.00	0.03	0.02	0.01	0.02	0.03	0.01	0.01
K <sub>2</sub> O	<0.10	<0.10	<0.10	<0.10	<0.10	0.02	0.02	0.02	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.01
P <sub>2</sub> O <sub>5</sub>	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
NiO	NA	NA	NA	NA	NA	0.00	0.01	0.07	0.02	0.00	0.00	0.01	0.00	0.00	0.06	0.01
<sup>c</sup> H <sub>2</sub> O <sub>calc</sub>	0.92	0.92	0.92	0.92	0.92	0.92	0.91	0.84	0.84	0.84	0.86	0.85	0.85	0.85	0.86	0.88
<b>Total</b>	<b>98.95</b>	<b>98.72</b>	<b>99.64</b>	<b>98.99</b>	<b>99.79</b>	<b>101.7</b>	<b>100.43</b>	<b>100.17</b>	<b>99.76</b>	<b>99.88</b>	<b>99.98</b>	<b>99.75</b>	<b>100.19</b>	<b>100.46</b>	<b>100.04</b>	

<sup>a</sup>FeO=Fe<sub>tot</sub> - (Na-Mg); <sup>b</sup>Fe<sub>2</sub>O<sub>3</sub>= Fe<sub>tot</sub>-FeO; (Groat et al., 2010)

<sup>c</sup>H<sub>2</sub>O<sub>calc</sub>: (0.84958\*Na<sub>2</sub>O)+0.8373 (Turner et al., 2007). NA- Not available

**Table 2** Trace Element Concentrations (ppm or mg/kg)

Trace Element s	Samples			
	1	2	3	4
Ba	<50	<50	<50	<50
Ga	<5	<5	<5	7.6
Sc	<3.5	<3.5	<3.5	<3.5
V	<20	<20	<20	<20
Th	5	8	8	6
Pb	4	8	5	5
Ni	<2	<2	<2	<2
Co	6	4	5	4
Rb	<5	<5	<5	<5
Sr	12	9	10	9
Y	5	<5	6.3	6.2
Zr	18	17	19	18
Nb	<5	<5	<5	<5
Cr	109	85	95	102
Cu	19	13	22	16
Zn	29	29	<10	14
Be	11.14	5.49	4.90	2.42
Ge	1.85	1.31	2.35	1.33
As	<5	<5	<5	<5
Sn	<5	<5	<5	<5
La	<1	3.00	<1	<1
Ce	<2	5.42	2.06	<2
Pr	<0.1	0.60	0.20	<0.10
Nd	<0.3	1.71	0.55	<0.3
Eu	0.04	0.03	0.02	<0.02
Sm	0.14	0.34	0.12	<0.1
Tb	0.01	0.03	0.01	<0.01
Gd	0.07	0.23	0.13	0.05
Dy	0.08	0.14	0.09	0.04
Ho	0.02	0.03	0.02	0.01
Er	0.04	0.06	0.08	0.03
Tm	<0.02	<0.02	<0.02	<0.02
Yb	0.05	0.07	0.06	0.03
Lu	0.01	0.01	0.01	<0.01
Hf	0.36	0.51	0.86	<0.2
Ta	<0.2	<0.2	<0.2	<0.2
U	0.59	0.76	0.70	0.68

### 4.3 Crystal Chemistry

The standard chemical composition of Chalcedony is SiO<sub>2</sub>. The structure of Chalcedony is an open three-dimensional framework consists of SiO<sub>4</sub> tetrahedra. So that the corners occupied with oxygens, each Si is bonded to four oxygens and each oxygen is bonded to two silicon atoms (<https://www.123rf.com/>).

The structural atoms are calculated based on 4 oxygens and presented in table 3.

**Table 3** Structural atoms calculated (based on 4 Oxygens)

Oxides	Analyzed with WD- XRF					Analyzed with EPMA									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Si	1.952	1.954	1.952	1.954	1.950	1.968	1.969	1.971	1.971	1.971	1.970	1.970	1.969	1.970	1.970
Ti	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Al	0.004	0.004	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe <sup>3+</sup>	0.014	0.012	0.014	0.011	0.016	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.001
Mn	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000
Mg	0.004	0.003	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.001
Na	0.004	0.004	0.004	0.004	0.004	0.003	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000
K	0.003	0.003	0.003	0.003	0.003	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ni	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001
H	0.124	0.124	0.123	0.123	0.123	0.120	0.120	0.111	0.112	0.112	0.114	0.113	0.113	0.112	0.114
<b>Total</b>	<b>2.106</b>	<b>2.106</b>	<b>2.104</b>	<b>2.103</b>	<b>2.104</b>	<b>2.093</b>	<b>2.091</b>	<b>2.085</b>	<b>2.085</b>	<b>2.085</b>	<b>2.087</b>	<b>2.086</b>	<b>2.086</b>	<b>2.086</b>	<b>2.087</b>

SiO<sub>2</sub> ranges from 96.71 to 100.58 with an average of 98.53. The number of Si atoms varies between 1.950 and 1.971 (Table 3). Ti, Al, Cr, Fe<sup>3+</sup>, Mn, Mg, Ca, Na, K, P, N and H<sub>2</sub>O are present in little amounts. Among these, Al occupies Si site, which varies in between 0.000 to 0.004 apfu. Iron varies in between 0.000 and 0.016. Mg Values lie between 0.000 and 0.004. Ca atoms varies from 0.000 to 0.002. Na atoms lie between 0.000 and 0.004. Others are insignificant in Kolluru area.

According to Deer et al., (1992), Al accompanied by Na occupy the Si site. With this substitution, the atoms are almost nearer to 2.000 in all the samples.

## 5. CONCLUSION

The samples collected from the Kolluru area, Guntur District, Andhra Pradesh, India, shows the highest weight percent of SiO<sub>2</sub> (max. 100), followed by Fe<sub>2</sub>O<sub>3</sub> (max. 1.06), H<sub>2</sub>O (max. 0.92), Al<sub>2</sub>O<sub>3</sub> (max. 0.16) and MgO (max. 0.12). The Remaining oxides are present in smaller quantities. Among the trace elements, Cr, Ba, Zn, Cu, V, Zr, Sr, Be, Th and Pb are present in higher concentrations. The other trace elements are noticed in negligible quantities. In all the samples, Si atoms are nearer to 2.000apfu. Based on the chemical composition and Si atoms, the study concluded that all the samples collected belong to Chalcedony varieties.

## ACKNOWLEDGMENT

The authors are grateful to the Director General, Geological Survey of India, Hyderabad, for the permission given to carry chemical analyses in their laboratories. The authors also thankful to Mr. B. Umamaheswar Rao, Consultant Hydrogeologist, Hyderabad, Dr. P. Raghuram and Dr. T. Rambabu, Assistant professors, SRKR Engineering College, Bhimavaram for their help in preparing the area and geology maps.

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