

# Study on Inclusions in Almandine Garnet from Vemireddipalle Area, Krishna District, Andhra Pradesh, India

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## ABSTRACT

Almandine Garnet is purplish red in colour. The mineral samples are collected from Vemireddipalle area, Krishna District, Andhra Pradesh. Dataset/points are examined using EPMA. It is found that  $P_2O_5$  (29.34%) and  $Ce_2O_3$  (22.47%) are abundant and the major oxides support the presence of Monazite inclusion. The high concentration of  $ZrO_2$  and  $SiO_2$  helped to confirm the other inclusion as Zircon.

**Keywords :** Almandine Garnet, Inclusion, Monazite, Zircon

## I. INTRODUCTION

The word garnet comes from the 14<sup>th</sup> –century Middle English word gernet, meaning 'dark red'. It is derived from the Latin granatus, from granum ('grain, seed') (<https://en.wikipedia.org/wiki/Garnet>). Garnets have been valued as gemstones for more than 5000 years (<https://www.wikigempedia.com/garnet.html>). The mineral samples are collected from Vemireddipalle area, Krishna District, Andhra Pradesh, India.

### Uses

- Garnets were used by Egyptian's jewellery as early as 3100BC. Also, garnet has been rose-cut, used as Bohemian garnet, since the Victorian era (<https://www.wikigempedia.com/garnet.html>).
- Garnets were used extensively in the historical bead-making industry of Arikamedu in Tamilnadu state (Gilg et al., 2018).
- Garnets are of importance as a jewel in the bearings of watches and scientific instruments.
- This mineral is used as an abrasive, either as garnet sandpaper or as a loose-grained powder for grinding and polishing plate glass (Jones, 1974).

- Garnet, a common replacement for silica sand in sandblasting (<https://www.reade.com/products/>).

### Previous studies

Inclusions present in Almandine Garnet were reported in the literature by various authors.

The study on Garibpet samples revealed the presence of quartz, zircon crystals, brownish goethite-bearing fracture, monazite, zircon and rutile were observed (Gilg et al., 2018). Bugoi et al., (2016) identified ilmenite, rutile, monazite, sillimanite and zircon inclusions in peitroasa and cluj-someseni treasures and Apahida samples. Monazite is reported from South India and Sri Lanka by Horvath and Bendo (2011). Thoresen and Schmetzer (2013) observed zircon crystals, monazite with strain halos, two-phase inclusions, rutile or ilmenite needles and apatite crystals in Almandine Garnet. Apatite, zircon, ilmenite, monazite, calcite and quartz inclusions were identified by Calligaro et al., (2002) from different countries (Indian, Ceylonese and Bohemian deposits). Wendt et al., (1993) reported quartz, apatite, zircon and rutile inclusions from Oman Mountains.

The aim of the present study is to identify the Inclusions of Almandine Garnet gemstone from Vemireddipalle area, Krishna district, Andhra Pradesh, India.

### II. METHODOLOGY

Fifteen dataset/points are examined by using Electron Probe Micro Analyses (EPMA). The samples are medium to dark purplish red in colour. By EPMA the following oxides were measured, i.e., P<sub>2</sub>O<sub>5</sub>, Ce<sub>2</sub>O<sub>3</sub>, ThO<sub>2</sub>, La<sub>2</sub>O<sub>3</sub>, Nd<sub>2</sub>O<sub>3</sub>, CaO, Pr<sub>2</sub>O<sub>3</sub>, Y<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, SmO, Gd<sub>2</sub>O<sub>3</sub>, PbO, UO<sub>2</sub>, FeO and ZrO<sub>2</sub>. Details are presented under Results and discussion.

### III. RESULTS AND DISCUSSION

In the study area, monazite and zircon inclusions are identified from the Almandine garnet samples. The details are presented in this section.

#### Monazite

From the EPMA analyses of five points, it is observed that the oxides of P<sub>2</sub>O<sub>5</sub>, Ce<sub>2</sub>O<sub>3</sub>, ThO<sub>2</sub>, La<sub>2</sub>O<sub>3</sub>, Nd<sub>2</sub>O<sub>3</sub> are present in higher quantities (Table 1 and Figure 1). P<sub>2</sub>O<sub>5</sub> varies in between 26.90 wt% and 29.34, followed by Ce<sub>2</sub>O<sub>3</sub> (21.95 to 22.47). ThO<sub>2</sub> lies between 16.84 to 19.58, La<sub>2</sub>O<sub>3</sub>, 11.54 to 12.09 and Nd<sub>2</sub>O<sub>3</sub>, from 8.62 to 8.89. CaO, Pr<sub>2</sub>O<sub>3</sub>, Y<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, SmO, Gd<sub>2</sub>O<sub>3</sub>, PbO, UO<sub>2</sub>, FeO and ZrO<sub>2</sub> are present in minor amounts. Based on the concentrations of P<sub>2</sub>O<sub>5</sub>, Ce<sub>2</sub>O<sub>3</sub>, ThO<sub>2</sub>, La<sub>2</sub>O<sub>3</sub> and Nd<sub>2</sub>O<sub>3</sub> the inclusion is identified as monazite (Plates 1 and 2).

TABLE 1  
EPMA ANALYSIS OF MONAZITE INCLUSIONS

Oxides	Data Points				
	1	2	3	4	5
P <sub>2</sub> O <sub>5</sub>	29.34	28.36	27.14	26.90	28.18
Ce <sub>2</sub> O <sub>3</sub>	22.02	22.41	21.95	22.22	22.47
ThO <sub>2</sub>	16.84	19.58	18.64	18.87	17.46
La <sub>2</sub> O <sub>3</sub>	11.93	11.89	12.03	12.09	11.54
Nd <sub>2</sub> O <sub>3</sub>	8.80	8.62	8.64	8.74	8.89
CaO	2.60	2.98	2.75	2.84	2.70
Pr <sub>2</sub> O <sub>3</sub>	1.88	2.02	2.15	1.92	2.14
Y <sub>2</sub> O <sub>3</sub>	1.85	0.11	0.12	0.14	0.50
SiO <sub>2</sub>	1.65	2.07	1.93	1.94	2.00
SmO	1.52	1.16	1.17	0.88	1.24
Gd <sub>2</sub> O <sub>3</sub>	1.02	0.51	0.30	0.16	0.95
PbO	0.47	0.55	0.52	0.57	0.41
UO <sub>2</sub>	0.76	1.05	1.15	1.11	0.95
FeO	0.14	0.19	0.09	0.43	1.16
ZrO <sub>2</sub>	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>100.84</b>	<b>101.49</b>	<b>98.56</b>	<b>98.80</b>	<b>100.59</b>

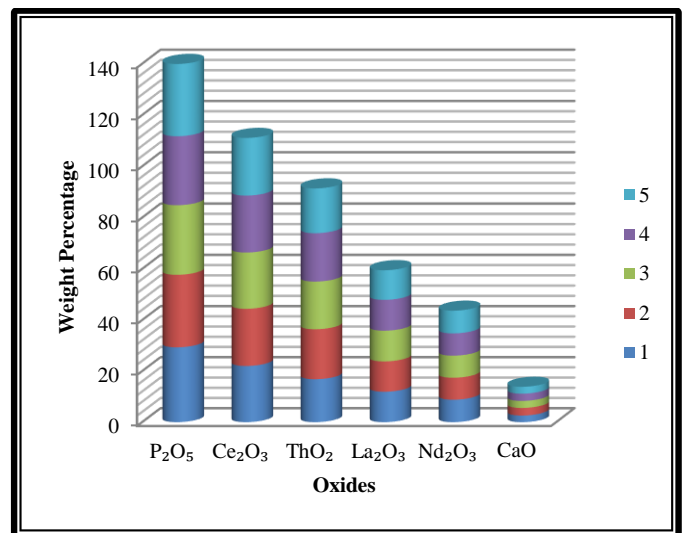


Figure 1 Oxides in Monazite

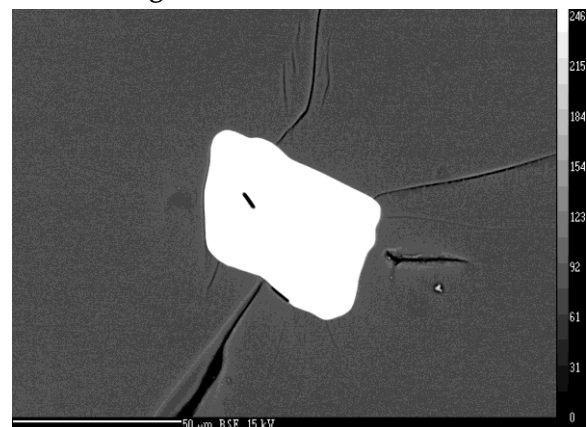


Plate 1 Monazite inclusions in Almandine Garnet

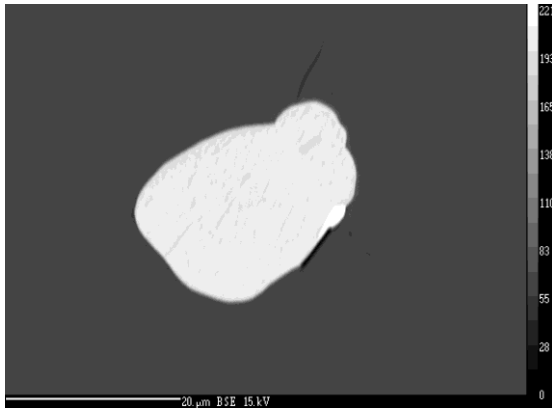


Plate 2 Monazite inclusions in Almandine garnet

### Zircon

ZrO<sub>2</sub> varies in between 64.34wt% and 66.57 in 10 data set points, at which the study was carried out. SiO<sub>2</sub> ranges from 29.68 to 33.19 and it is followed by FeO, which lies between 0.75 and 1.46. UO<sub>2</sub>, P<sub>2</sub>O<sub>5</sub>, Nd<sub>2</sub>O<sub>3</sub>, CaO, Y<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Ce<sub>2</sub>O<sub>3</sub>, Pr<sub>2</sub>O<sub>3</sub>, SmO, Gd<sub>2</sub>O<sub>3</sub> and ThO<sub>2</sub> are noticed in lesser quantities. High concentrations of ZrO<sub>2</sub> and SiO<sub>2</sub> revealed that the inclusion is zircon (Table 2 and Plates 3 and 4).

**Table 2.** EPMA analysis of Zircon inclusions

Oxides	Data Points									
	1	2	3	4	5	6	7	8	9	10
ZrO <sub>2</sub>	64.52	66.57	65.20	66.32	64.34	65.54	65.61	65.63	65.26	64.77
SiO <sub>2</sub>	32.84	31.03	32.33	29.68	33.19	33.11	32.49	32.46	32.54	32.64
FeO	1.46	1.05	0.89	0.91	0.96	1.08	1.05	0.90	1.90	0.75
UO <sub>2</sub>	0.38	0.44	0.27	0.32	0.02	0.00	0.22	0.22	0.35	0.20
P <sub>2</sub> O <sub>5</sub>	0.30	0.25	0.28	0.29	0.31	0.44	0.36	0.35	0.31	0.46
PbO	0.08	0.01	0.00	0.02	0.02	0.00	0.03	0.00	0.02	0.03
Nd <sub>2</sub> O <sub>3</sub>	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.02	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.04	0.00
Y <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.04
La <sub>2</sub> O <sub>3</sub>	0.00	0.03	0.00	0.14	0.10	0.00	0.02	0.09	0.00	0.08
Ce <sub>2</sub> O <sub>3</sub>	0.00	0.06	0.00	0.06	0.02	0.09	0.08	0.10	0.00	0.00
Pr <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.03	0.00
SmO	0.00	0.00	0.01	0.15	0.00	0.09	0.31	0.03	0.07	0.00
Gd <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.03	0.18	0.04	0.00	0.00	0.20	0.00	0.00
ThO <sub>2</sub>	0.00	0.05	0.01	0.00	0.03	0.00	0.00	0.03	0.03	0.04
<b>Total</b>	<b>99.64</b>	<b>99.56</b>	<b>99.03</b>	<b>98.05</b>	<b>99.11</b>	<b>100.39</b>	<b>100.19</b>	<b>99.99</b>	<b>100.53</b>	<b>99.01</b>

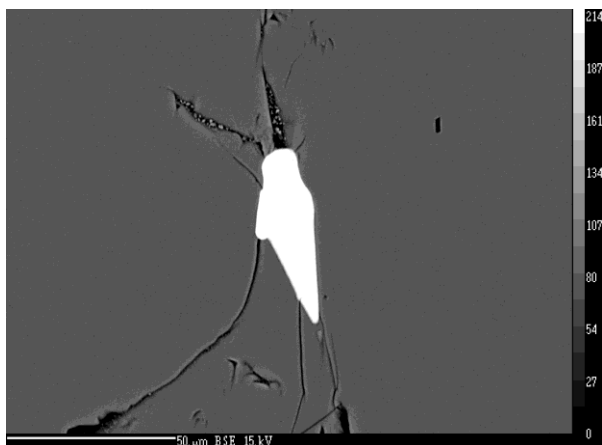


Plate 3 Zircon Inclusions in Almandine Garnet

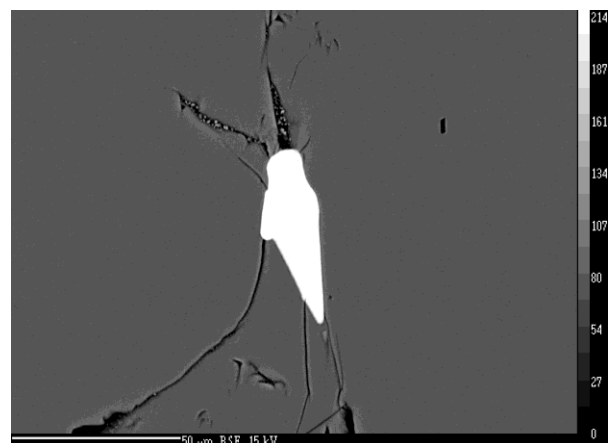


Plate 4 Zircon Inclusions in Almandine Garnet

The EPMA analyses confirmed the presence of Monazite and Zircon inclusions.

## II. CONCLUSION

The mineral samples collected from Vemireddipalle area are subjected to EPMA analyses for the identification of inclusions. Based on the EPMA analyses Monazite and Zircon inclusions are identified from the samples.

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