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ANALYSIS OF MINERALS IN CEMPAKA-MADU GEMSTONE FROM ACEH INDONESIA BY USING XRF

Ismail*, Akmal Nizar, Mursal

Department of Physics, Faculty of Mathematics and Natural Science, Syiah Kuala University, Banda Aceh 23111, Indonesia
*corresponding Author E-mail: ismailab@unsyiah.ac.id

Abstract. Cempaka-madu is a local name for one kind of gemstone from Aceh province in Indonesia. It is so attractive and its color is dark-orange. We have utilized X-Ray Florescent (XRF) to study these cempaka-madu gemstones from Aceh Tengah and Nagan Raya districts in Aceh province. Our results show that the cempaka-madu gemstone from Nagan Raya district contains 84.90% of SiO_2, 8.89% of NiO, 5.47% of Fe_2O_3, and 0.6% of CaO. The mineral contains in cempaka-madu gemstone from Aceh Tengah district is about the same as those from Nagan Raya district. It is found that the oxide compounds contained in the cempaka-madu gemstone is significantly different than that in jadeite, nephrite-actinolite, nephrite-tremolite, serpentine-clinochrysotile, serpentine-antigoride, and vesuvianite. Consequently, we conclude that the cempaka-madu gemstone from Aceh Indonesia cannot be categorized as jade.

Keywords: cempaka-madu gemstone, jade, jadeite, nephrite, serpentine, vesuvianite

I INTRODUCTION

Jade is a very well known gemstone in the worldwide. Some people use jade for medicinal purposes and ornaments. But most people use jade as jewelry. Jade is found in some places in the world, including in Indonesia such as in West Sumatra, North Sumatra, and Aceh. Nonetheless, natural jade is rare and highly valued [1]. Jade is considered as either jadeite or nephrite [2, 4] even though the mineral contents in jadeite and nephrite are different. Jadeite is composed by $Na(Al,Fe)\ Si_2O_6$, while nephrite is categorized into tremolite or antigorite which is composed by $Ca_2\ (Mg,Fe)_5\ Si_8O_{22}\ (OH)_2$. Serpentine and vesuvianite are also categorized as jade which are called as serpentine-jade and vesuvianite-jade. The study on jade has been conducted intensively. Recent study shows that the jade from Turkey contains 63.54% of SiO_2, 20.17% of Al_2O_3, 6.71% of Na_2O, 1.78% of Fe_2O_3, and 2.7% of CaO [5]. This Turkish jade can be categorized as jadeite-jade. Nurul Aflah *et al* found that the various types of jade from Beutong Aceh Indonesia are the results of the existence of a melance path in the area [6]. Akmal *et al* found that bio-solar gemstone from Aceh Indonesia contains minerals of CaO (59.8%), SiO2 (19.7%), Fe2O3 (11.1%), Al2O3 (7.5%), and NiO (1.3%) [7]. It is found that this bio-solar gemstone is a type of vesuvianite-jade [7]. Ismail *et al* found that gemstone black-jade from Aceh Tengah contains 39.6% of SiO_2, 35% of Fe_2O_3, 17% of MgO, 3% of CaO, and 2% of NiO. It is suggested that the black-jade gemstone from Aceh Indonesia is a type of serpentine-antigoride-jade [8]. Cempaka-madu is a local name for a well known gemstone from Aceh, Indonesia. Its color is dark-orange. This gemstone is so pretty and quite popular which was ranked into the first rank in the Indonesian Gemstone Stone Contest in Jakarta in 2014. Nonetheless, it is still unknown what kinds of minerals contained in this gemstone. It is unknown whether this gemstone can be categorized as a type of jade or not. Thus, we have studied the mineral contents in cempaka-madu gemstone from Aceh Indonesia by using X-Ray Fluorescent (XRF). The results are compared with the previously published mineral data and reported in this paper.

II METHODS

The samples of cempaka-madu gemstone used in this study were obtained from Aceh Tengah (Takengon) and Nagan Raya districts, Aceh Province, Indonesia (figure 1). The samples of cempaka-madu gemstone were crushed into powder. X-Ray Florescent (XRF), Brand of PANalytical MiniPal Type 4 was used to obtain the mineral contents from cempaka-madu gemstone. The data were collected at room temperature. Data of cempaka-madu gemstone is compared to jade data that are already available in the gemstone database [9-14].

Figure 1 Cempaka-Madu Gemstone

III RESULTS AND DISCUSSION

Table 1 shows our XRF measurement results of cempaka-madu gemstones from Nagan Raya and Aceh Tengah districts Aceh province, Indonesia. The cempaka-madu gemstone from Nagan Raya district contains 84.90% of SiO_2, 8.89% of NiO, 5.47% of Fe_2O_3, and 0.6% of CaO. The cempaka-madu gemstone from Takengon (Aceh Tengah district) is also mainly contains SiO_2 (81.10%), but its number is a little bit smaller than that in cempaka-madu from Nagan Raya. Its different is 3.8% (see Table 1).

Table 1 XRF data of cempaka-madu gemstone (CMG) from Nagan Raya and Aceh Tengah (Takengon) districts Aceh

Type of oxides	Composition CMG Nagan Raya(%)	Composition CMG Takengon(%)	Diffe-rence (%)
SiO_2	84.90	81.10	3.8
NiO	8.89	5.21	3.7
Fe_2O_3	5.47	8.03	2.6
CaO	0.60	2.09	1.5
P_2O_5	0	2.60	2.6
		Total	14.1
		Average	2.8

The cempaka-madu gemstone from Takengon contains 5.21% of NiO, 8.03% of Fe_2O_3, 2.09% of CaO, and 2.60% of P_2O_5. As shown in Table 1, the total difference between minerals contained in cempak-madu from Nagan Raya and Takengon is 14.1% and its average difference is only 2.8%. Obviously, the mineral contains in cempaka-madu gemstone from Aceh Tengah district (Takengon) is the same as that from Nagan Raya district. In order to determine whether this cempaka-madu gemstone can be categorized as jade or not, we compare the composition of the cempaka-madu gemstone with some previously published jade data. In this case we will use the data of the cempaka-madu gemstone from Nagan Raya district, Aceh. Table 2 shows the comparison of oxide compound compositions in cempaka-madu gemstone with jadeite [9]. Cempaka-madu gemstone contains 84.9% of SiO_2; however jadeite contains only 58.61% of SiO_2. Its difference is 26.29%. Cempaka-madu gemstone contains 8.89% of NiO, however this mineral is not found in the jadeite. Jadeite contains 22.38% of Al_2O_3 and 15.11% of Na_2O, but these minerals are not contained at all in cempaka-madu gemstone. Both cempaka-madu and jadeite contains Fe_2O_3 and its number is about the same. The total difference between minerals contained in cempaka-madu gemstone and jadeite is 74.85% and its average difference is 12.48%.

Table 2 Comparison oxide compound compositions in cempaka-madu with jadeite

Type of oxides	Cempaka-madu (%)	Jadeite (%)	Difference (%)
SiO_2	84.9	58.61	26.29
NiO	8.89	0	8.89
Al_2O_3	0	22.38	22.38
Na_2O	0	15.11	15.11
Fe_2O_3	5.47	3.89	1.58
CaO	0.6	0	0.6
		Total	74.85
		Average	12.48

Table 3 Comparison of oxide compound compositions in cempaka-madu with nephrite actinolite

Type of oxides	Cempaka-madu (%)	Nephrite Actinolite (%)	Difference (%)
SiO_2	84.9	54.86	30.04
NiO	8.89	0	8.89
Fe_2O_3	5.47	0.47	5
MgO	0	16.11	16.11
CaO	0.6	12.03	11.43
FeO	0	10.61	10.61
		Total	82.08
		Average	13.68

Next, we compare the mineral composition of the cempaka-madu gemstone with nephrite actinolite [10] as shown in Table 3. Nephrite actinolite contains only 54.86% SiO_2 which is much less than that in cempaka-madu gemstone. Its difference is 30.04%. Nephrite actinolite does not contain NiO at all but it contains 16.11% of MgO, 12.03% of CaO, and 10.61% of FeO while cempaka-madu gemstone contains only 0.6% of CaO and it does not contain MgO and FeO. As shown in Table 3, its total difference is 82.08% and its average difference is 13.68%. Subsequently, we compare the mineral composition of the cempaka-madu gemstone with nephrite tremolite [11] as shown in Table 4. Both cempaka-madu gemstone and nephrite tremolite contain SiO_2, but their percentages are quite different (the difference is 25.7%). Nephrite tremolite does not contain

NiO and Fe_2O_3. It contains 24.8% of MgO and 13.8% of CaO. The total difference of mineral composition in cempaka-madu and nephrite tremolite is 78.06% and its average difference is 15.61%.

Table 4 Comparison of oxide compound compositions in cempaka-madu with nephrite tremolite

Type of oxides	Cempaka-madu (%)	Nephrite Tremolite (%)	Difference (%)
SiO_2	84.9	59.2	25.7
NiO	8.89	0	8.89
Fe_2O_3	5.47	0	5.47
MgO	0	24.8	24.8
CaO	0.6	13.8	13.2
		Total	78.06
		Average	15.61

We compare the mineral composition of the cempaka-madu gemstone with serpentine clinochrysotile [12] as shown in Table 5. The cempaka-madu gemstone contains 84.9% of SiO_2 which is much larger than that in the serpentine clinochrysotile (43.36%). Its difference is 41.54%. The cempaka-madu gemstone contains 8.89% of NiO and 5.47% of Fe_2O_3, but serpentine clinochrysotile does not contain these compounds at all. The serpentine clinochrysotile contains 43.63% of MgO and 13% of H_2O while cempaka-madu gemstone does not contain these compounds at all. The total difference of mineral composition in cempaka-madu and serpentine clinochrysotile is 113.13% and its average difference is 18.86%.

Table 5 Comparison of oxide compound compositions in cempaka-madu with serpentine clinochrysotile

Type of oxides	Cempaka madu (%)	Serpentine Clinochrysotile (%)	Difference (%)
SiO_2	84.9	43.36	41.54
NiO	8.89	0	8.89
Fe_2O_3	5.47	0	5.47
MgO	0	43.63	43.63
CaO	0.6	0	0.6
H_2O	0	13	13
		Total	113.13
		Average	18.86

Table 6 shows the comparison of composition of oxide compound in cempaka-madu and serpentine antigoride [13]. The cempaka-madu gemstone contains 84.9% of SiO_2 while serpentine antigoride contains only 39.9% of SiO_2. Its difference is 45%. The cempaka-madu gemstone contains 8.89% of NiO while this compound is not contained in the serpentine antigoride. The cempaka-madu gemstone contains 5.47% of Fe_2O_3 which is almost similar to serpentine antigoride. However, the serpentine antigoride contains 30.15% of MgO and 12% of H_2O while cempaka-madu gemstone does not contain these compounds at all. The total difference of mineral composition in cempaka-madu and serpentine antigoride is 109% and its average difference is 18.2%.

Table 6 Comparison of oxide compound compositions in cempaka-madu with serpentine antigoride

Type of oxides	Cempaka-madu (%)	Serpentine Antigoride (%)	Difference (%)
SiO_2	84.9	39.9	45
NiO	8.89	0	8.89
Fe_2O_3	5.47	17.92	12.45
MgO	0	30.15	30.15
CaO	0.6	0	0.6
H_2O	0	11.98	11.98
		Total	109.07
		Average	18.18

Table 7 Comparison of oxide compound compositions in cempaka-madu with vesuvianite

Type of oxides	Cempaka madu (%)	Vesuvia-nite (%)	Diffe-rence (%)
SiO_2	84.9	38.03	46.87
NiO	8.89	0	8.89
Al_2O_3	0	14.34	14.34
Fe_2O_3	5.47	0	5.47
MgO	0	5.67	5.67
CaO	0.6	39.43	38.83
		Total	120.07
		Average	20.01

Table 8 Total and average differences oxide compositions in cempaka-madu and other gemstones

Kind of Gemstone	Total Difference (%)	Average Difference (%)
Jadeite	74.85	12.48
Nephrite-Actinolite	82.08	13.68
Nephrite-Tremolite	78.06	15.61
Serpentine-Clinochrysotile	113.13	18.86
Serpentine-Antigoride	109.07	18.18
Vesuvianite	120.07	20.01

Table 7 shows the comparison of composition of oxide compound in cempaka-madu and vesuvianite [14]. The cempaka-madu gemstone contains 84.9% of SiO_2 while vesuvianite contains only 38% of SiO_2. Its difference is 46.87%. The vesuvianite does not contain NiO and Fe_2O_3 while the cempaka-madu does. But, vesuvianite contains 14.34% of Al2O3, 5.67% of MgO, and 39.43% of CaO which is so different than the cempaka-madu. The total

difference of mineral composition in cempaka-madu and vesuvianite is 120% and its average difference is 20%. The lowest total difference is 74.85% and average difference is 12.48%, which is jadeite. However, the cempaka-madu does not contain Al_2O_3 and Na_2O at all while both these compounds are found in the jadeite. Another large discrepancy is the percentage if SiO_2 compound where it is only 59% in jadeite, while it is 85% in the cempaka-madu gemstone. Thus, the cempaka-madu cannot be categorized as jadeite.

CONCLUSION

The cempaka-madu gemstone from Aceh Indonesia contains 84.90% of SiO_2, 8.89% of NiO, 5.47% of Fe_2O_3, and 0.6% of CaO. The mineral contains in cempaka-madu gemstone from Aceh Tengah district is about the same as those from Nagan Raya district. The percentage of oxide compounds contained in the cempaka-madu gemstone is significantly different than that in jadeite, nephrite-actinolite, nephrite-tremolite, serpentine-clinochrysotile, serpentine-antigoride, and vesuvianite. Thus, we conclude that the cempaka-madu gemstone from Aceh Indonesia cannot be categorized as jade.

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