Mineral identification of black-jade gemstone from Aceh Indonesia

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Abstract. One of the gemstones in Aceh Indonesia is called black-jade where the name of black-jade is a local name. Unfortunately, detail information about this gemstone is still limited. No one knows whether this gemstone can be categorized as jade or not until this study is presented. We have utilized X-Ray Fluorescent (XRF) to study the black-jade gemstone from Aceh Tengah (Takengon) and Nagan Raya regions in Indonesia. Our results show that the black-jade gemstone from Aceh Tengah contains 39.6% of SiO₂, 35% of Fe₂O₃, 17% of MgO, 3% of CaO, and 2% of NiO. While, the black-jade gemstone from Nagan Raya contains a little bit less SiO₂ but more Fe₂O₃ than that of black-jade from Aceh Tengah: 38.4% of SiO₂, 39% of Fe₂O₃, 17% of MgO, 0.5% of CaO, and 2.6% of NiO. By comparing the results to the available mineral data (jadeite, nephrite-actinolite, nephrite-tremolite, serpentine-clinochrysotile, serpentine-antigorite, and vesuvianite), we found that oxide compounds contained in the black-jade gemstone from Aceh are found in the serpentine-antigorite, except H₂O. The total difference between the oxide compositions in black-jade and serpentine-antigorite is 43% with its average difference of 11%. This means that the oxide composition in black-jade is almost the same as in the serpentine-antigorite. Accordingly, the black-jade gemstone from Aceh Indonesia is a type of serpentine-antigorite-jade.

1. Introduction

Jade is one of the popular gemstones in the worldwide. People use jade for medicinal purposes, jewelry, ornaments, and religious artifacts. In Chinese, jade symbolizes nobility, perfection, constancy, and immortality. The gemstone is known for many fine nuances of green, but also in shades of white, black, gray, yellow, orange, and violet. Jade is a natural gemstone which is rare and highly valued [1]. Jade is found in many places in the world, such as in Burma, Myanmar, United States, Russia, British, Canada, Turkey, and Indonesia. In Indonesia, jade is found in several areas such as West Sumatra, North Sumatra, and Aceh.

Some studies on jade have been done previously. Jade is considered as the minerals composed of either nephrite or jadeite [2, 4]. However, their chemical compositions are different [4]. Nephrite is categorized into group tremolite or antigorite composed by Ca₂ (Mg₅Fe)Si₈O₂₂ (OH)₂Si₂O₆. While jadeite is group pyroxene composed of Na(Al,Fe)Si₂O₆. Serpentine and vesuvianite can also be categorized as jade which is called as serpentine-jade and vesuvianite-jade. A Recent study shows that Turkish purple jade contains 63.54% of SiO₂, 20.17% of Al₂O₃, 6.71% of Na₂O, 1.78% of Fe₂O₃, and 2.7% of CaO [5]. This Turkish purple jade can be categorized as jadeite-jade.

Recently, gemstones from Aceh Indonesia are quite popular. These gemstones were ranked into the first rank in the Indonesian Gemstone Stone Contest in Jakarta in 2014. Nonetheless, the research on
precious stones in Aceh is still limited. Nurul Aflah et al. researched jade from the mountain Beutong Aceh. They found that the various types of jade from the area mentioned above are the result of the existence of a steady path in the area [6]. Akmal et al. have identified the mineral content in the bio-solar gemstone from Aceh. They found that bio-solar gemstone contains minerals of CaO (59.8%), SiO₂ (19.7%), Fe₂O₃ (11.1%), Al₂O₃ (7.5%), and NiO (1.3%) [7]. By comparing their results with the international mineral database, they found that the bio-solar gemstone from Aceh is a type of vesuvianite [7]. Another Aceh's famous gemstone is called “black-jade.” The name of black-jade is a local name. However, what kind of minerals contained in this precious stone is still unknown. It is unknown whether this gemstone can be categorized as a type of jade or not.

We have identified the mineral contents in black-jade 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.

2. Experimental Details
The samples of black-jade gemstone used in this study were obtained from Nagan Raya and Aceh Tengah districts in Aceh, Indonesia. The color of black-jade gemstone from Aceh is dark green, and it is beautiful as shown in figure 1.

![Figure 1. Black-Jade Gemstone from Aceh.](image)

The sample of black-jade gemstone was crushed into powder. Identification of mineral content from black-jade gemstone sample from Aceh was conducted by using X-Ray Fluorescent (XRF), Brand of PANalytical MiniPal Type 4. The experiment was performed in the Laboratorium Sentral Mineral FMIPA Universitas Negeri Malang, Indonesia. Data were collected at room temperature.

3. Results and Discussions
By using XRF, we found that the black-jade gemstone from Aceh Tengah Indonesia contains 39.6% of SiO₂, 35% of Fe₂O₃, 17% of MgO, 3% of CaO, and 2% of NiO. While, the black-jade gemstone from Nagan Raya contains a little bit less SiO₂ but more Fe₂O₃ than that of black-jade from Aceh Tengah: 38.4% of SiO₂, 39% of Fe₂O₃, 17% of MgO, 0.5% of CaO, and 2.6% of NiO. In general, the compounds contained in the black-jade from Aceh Tengah are the same as that from Nagan Raya. Detail compounds or minerals contained in black-jade gemstone are listed in table 1.

The next step is to compare the composition of the black-jade gemstone above with some previously published jade data as shown in table 2. In this case, we use the data of the black-jade gemstone from Aceh Tengah (Takengon). The comparison is made only for the composition greater than or equal to 5%, while data content of compound below 5% is ignored. The oxide compounds in black-jade from Aceh (result from this work) are compared with jadeite, nephrite-actinolite, nephrite-tremolite, serpentine-clinochrysoite, serpentine-antigorite, and vesuvianite.
Table 1. The content of oxide compounds in black-jade gemstone by using XRF.

| Type of oxides | Composition (%) Black-jade Nagan Raya | Composition (%) Black-jade Takengon |
|---------------|--------------------------------------|-------------------------------------|
| Fe$_2$O$_3$   | 38.9                                 | 35.1                                |
| SiO$_2$       | 38.4                                 | 39.6                                |
| MgO           | 17.0                                 | 17.0                                |
| NiO           | 2.62                                 | 2.13                                |
| Cr$_2$O$_3$   | 1.35                                 | 1.37                                |
| P$_2$O$_5$    | 0.66                                 | -                                   |
| MnO           | 0.44                                 | 0.79                                |
| CaO           | 0.42                                 | 3.28                                |
| Re$_2$O$_7$   | 0.10                                 | -                                   |
| ZnO           | 0.04                                 | 0.79                                |
| La$_2$O$_3$   | 0.07                                 | 0.05                                |

Table 2. Comparison of the composition of oxide compounds contained in black-jade with the oxide content in other gemstones

| Type of oxides | Black-jade (%) | Jadeite (%) | Nephrite Actinolite (%) | Nephrite Tremolite (%) | Serpentine Clinohydrite (%) | Serpentine Antigorite (%) | Vesuvianite (%) |
|---------------|----------------|-------------|-------------------------|------------------------|-----------------------------|---------------------------|-----------------|
| SiO$_2$       | 39.60          | 58.61       | 54.86                   | 59.20                  | 43.36                       | 39.90                     | 38.03           |
| Al$_2$O$_3$   | 0              | 22.38       | 0                       | 0                      | 0                           | 0                         | 14.34           |
| Na$_2$O       | 0              | 15.11       | 0                       | 0                      | 0                           | 0                         | 0               |
| Fe$_2$O$_3$   | 35.10          | 3.89        | 0.47                    | 0                      | 0                           | 17.92                     | 0               |
| MgO           | 17.00          | 0           | 16.11                   | 24.80                  | 43.63                       | 30.15                     | 5.67            |
| CaO           | 0              | 0           | 12.03                   | 13.80                  | 0                           | 0                         | 39.43           |
| FeO           | 0              | 0           | 10.61                   | 0                      | 0                           | 0                         | 0               |
| H$_2$O        | 0              | 0           | 0                       | 0                      | 13.00                       | 11.98                     | 0               |

First, let’s compare black-jade with jadeite. From the table 2, we find that the main oxide contained in jadeite is SiO$_2$ which is 58.61%. Black-jade also contains SiO$_2$, but it is only 39.60%. The difference between SiO$_2$ composition in black-jade and SiO$_2$ composition in jadeite is about 19%. Black-jade does not contain Al$_2$O$_3$ and Na$_2$O. However, jadeite includes 22.38% of Al$_2$O$_3$ and 15.11% of Na$_2$O. Black-jade contains 35.1% of Fe$_2$O$_3$ while it is only 3.89% in jadeite. Its difference is about 31%. Furthermore, black-jade includes 17% of MgO while jadeite does not contain MgO at all. The total difference between oxide compositions in black-jade and jadeite is 105%, and its average is 21%. The summary of comparison between the oxide composition in black-jade and jadeite is listed in table 3.
Table 3. The composition of oxide compounds in black-jade with jadeite.

| Type of oxides | Jadeite (%) | Black-jade (%) | Difference (%) |
|----------------|-------------|----------------|----------------|
| SiO₂           | 58.61       | 39.60          | 19.01          |
| Al₂O₃          | 22.38       | 0              | 22.38          |
| Na₂O           | 15.11       | 0              | 15.11          |
| Fe₂O₃          | 3.89        | 35.10          | 31.21          |
| MgO            | 0           | 17.00          | 17.00          |
| Total Difference |            |                | 105            |
| Average Difference |        |                | 21             |

Similarly, we compare the oxide composition in black-jade with nephrite-actinolite. Table 2 shows that nephrite-actinolite contains 54.86% of SiO₂. But black-jade contains only 39.60% of SiO₂. Its difference is about 15%. The largest difference between oxide compositions in black-jade and nephrite-actinolite is Fe₂O₃ that is 34.6%. The total difference between oxide compositions in black-jade and nephrite-actinolite is 70%, and its average is 14%. Next, let’s compare black-jade with nephrite-tremolite. As shown in table 2 nephrite-tremolite contains 59.20% of SiO₂. But black-jade contains only 39.60% of SiO₂. Its difference is about 19.6%. Nephrite-tremolite contains 24.80% of MgO and 13.80% of CaO which are similar to black-jade. The largest difference between oxide compositions in black-jade and nephrite-tremolite is Fe₂O₃ that is 35.1%. The total difference between oxide compositions in black-jade and nephrite-tremolite is 73%, and its average is 18%. Subsequently, let’s compare black-jade with serpentine-clinochrysotile. From table 2, we can see that the composition of SiO₂ in black-jade is almost the same as in serpentine-clinochrysotile. However, it is quite different for the composition of Fe₂O₃ which is 0% in serpentine-clinochrysotile, but it is 35.15% in black-jade. On the other hand, serpentine-contains 13% of H₂O which is 0% in black-jade. Serpentine-clinochrysotile contains 43.63% of MgO which is much less in black-jade, it is only 17%. The total difference between oxide compositions in black-jade and serpentine-clinochrysotile is 79%, and its average is 20%. Next, let’s compare black-jade with serpentine-antigoride. From the table 2, we find that the main oxide contained in jadeite is SiO₂ which is 39.90% which is about the same as in black-jade. Serpentine-antigoride contains 17.92% of Fe₂O₃ which is smaller than that in black-jade. Serpentine-antigoride contains 30.15% of MgO which is larger than that in black-jade. Serpentine-antigoride also contains 11.98% of H₂O, but it is 0% in black-jade. The total difference between oxide compositions in black-jade and serpentine-antigoride is 43%, and its average is 11%. The last one, let’s compare black-jade with vesuvianite. From the table 2, we find that the main oxide contained in vesuvianite is CaO which is 39.43%. But CaO compound is about 0% in black-jade. Vesuvianite contains 38.03% of SiO₂ which is about the same as in black-jade. Vesuvianite also contains 14.34% of Al₂O₃. However, black-jade does not contain this compound. Vesuvianite contains 5.67% of MgO which is smaller than that in black-jade. The total difference between oxide compositions in black-jade and vesuvianite is 98%, and its average is 20%. The summary of comparison between black-jade gemstone and other six kinds of gemstones is listed in table 4.
When we compare black-jade to jadeite, we found that its total difference is 105% and its average difference is 21%. These mean that black-jade is not jadeite because the composition of oxides in black-jade is so different than that in jadeite. Table 4 shows that the smallest total difference of oxide compositions in black-jade with other six gemstones is serpentine-antigorite that is 43% with its average difference of 11%. These mean that the oxide compositions in black-jade are almost the same as in serpentine-antigorite. As shown in Table 2, all minerals contained in the gemstone black-jade are found in the serpentine-antigorite, except H2O. Therefore, the black-jade is a type of serpentine-antigorite.

4. Conclusions

The gemstone black-jade from Aceh Tengah contains 39.6% of SiO₂, 35% of Fe₂O₃, 17% of MgO, 3% of CaO, and 2% of NiO. The oxide compounds contained in black-jade gemstone from Aceh Tengah and Nagan Raya Aceh are about the same. It is found that all minerals contained in the gemstone black-jade from Aceh are found in the serpentine-antigorite, except H₂O. The total difference between oxide compositions in black-jade and serpentine-antigorite is 43% with its average difference of 11%. Thus, we conclude that the black-jade gemstone from Aceh Indonesia is a type of serpentine-antigorite-jade. This finding is essential for gemstone society in Indonesia. All gemstones from Indonesia should be studied to obtain their specifications. Thus, it is interesting to identify minerals contained in other gemstones from Indonesia which are not identified yet.

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