A note on a new occurrence of a gem-shaped mineral of jadeite family in the island of Madagascar

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Abstract

A new occurrence of a gem-shaped mineral of jadeite family in the island of Madagascar was studied. By conducting several methods of characterization, the physical and chemical parameters obtained were used to define the mineralogical nature of the analyzed minerals samples. This study shows that these gem-shaped minerals with relatively high manganese content belong to the family of jadeite. Their usually green-blue color in daylight turns into reddish in yellow light. This color change can be attributed to the presence of transition elements in small quantities. The jade is called ranoarivonite.

Keywords: Gem stone, chemical properties, hardness, specific gravity, refractive index, jadeite, Madagascar.

1. INTRODUCTION

The island of Madagascar, which lies in the southwest of the Indian Ocean, has a wide range of gemstones.

However, because of worries and quality constraints in commercial practice, research on the mineralogical identification and physical characterization of these minerals is a necessity. A special care must be done on the chemical characterization leading to the identification of chemical constituents.

In this work, we review the many facets of physical and chemical characterizations of gem-shaped samples with the aim of identifying them. We hope to better inform the reader about this aspect of gemology.

All analyses were conducted in Madagascar, within the Polytechnic Superior School of the University of Antananarivo, in the Geotechnology Laboratory and in the Chemical Engineering Laboratory.

2. MATERIALS AND METHODS

2.1. Equipment and tools

Visual observations and descriptions were carefully carried under the microscope. Physical and chemical characterization methods were used.
The samples were weighed and crushed (Figures 1, 2 and 3).
We took twenty six pieces of samples with a total mass of 31.36 grams.

Figure 1: Green-blue colored samples

Figure 2: Green-brownish to green-pinkish colored samples

Figure 3: Weighing of samples

2.2. Physical characterization

Gems characterization works are many. We used the following devices and techniques:

- ✓ Spectrophotometer UV/VIS Perkin Elmer Lambda 10
- ✓ Atomic absorption spectrometer: Perkin Elmer Analyst-100
- ✓ Infrared spectrometer: Spectrum-RFX.FT.IR System
- ✓ Specific gravity meter (Figure 4)
- ✓ Classic refractometer
- ✓ Presidium Duo Tester (Figure 5) for calculating reflective index
- ✓ Jadeite Filter (Figure 6)

Figure 4: Photography of specific gravity meter

Figure 5: Photography of Presidium Duo Tester

Figure 5: Photography of Jadeite Filter

The details of these techniques can be found on the internet [1] [2] [3] [4] or in other books.

For physical and mineralogical characterization, optical methods and physical methods for determining parameters such as hardness, density and optical and spectral absorption properties were adopted.

2.3. Chemical characterization

Several assays of elements present in the samples were performed and according to appropriate methods to the subject elements. For chemical characterization, the work processes to be performed is described in Figure 4.

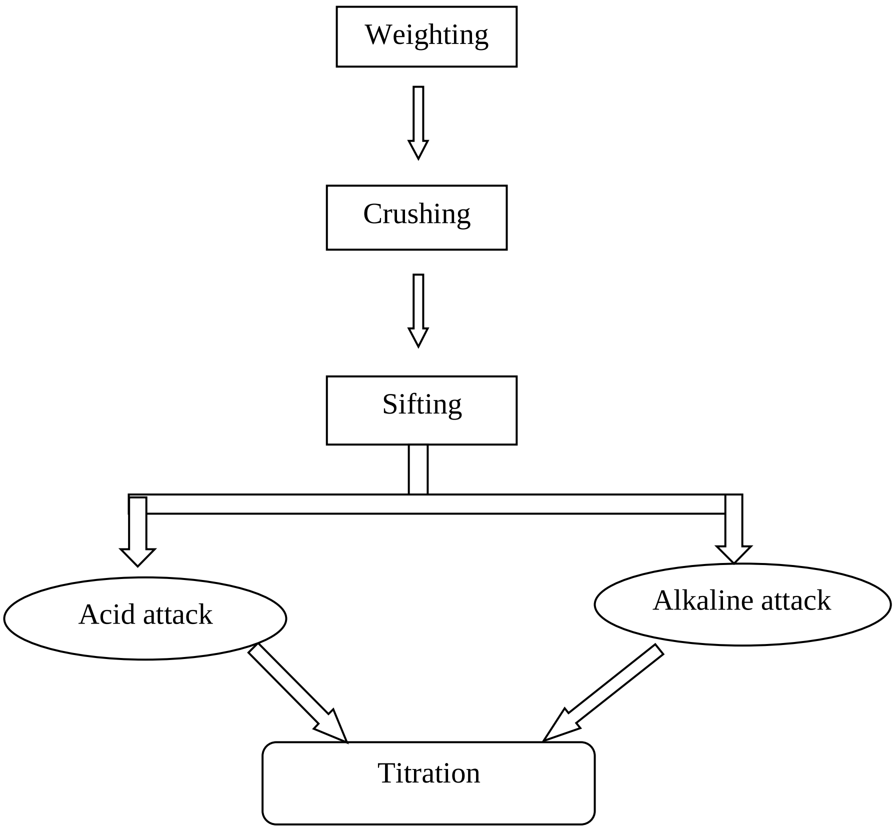

Figure 4: Diagram of the chemical characterization stages

2.3.1. <u>Silica determination</u>

- Weigh the platinum crucible: let say m
- Place the paper and its contents in the crucible, dry on plate
- Calcine at 1175 ± 25°C during 45 minutes
- Let cool in a dryer
- Weigh and check the consistency of the mass: let say m'

The expression of results is done according to the formula
% SiO_2 = (m'- m) x 100

with m = empty mass of crucible
m’ = mass of crucible + after calcination

2.3.2. Determination of Fe_2O_3

- Pipette 100 ml of the filtrate, add 200 ml of E.D
- Add 0.5 grams of amino-acetic acid and 0.3 grams of sulfosalicylic indicator
- Add to pH 1.5 ± 0.1 for uploading NH_4OH 1+1 or 1+10
- Heat at 47.5 ° C ± 25% (never exceed 50° C)
- Add 2 ml of H_2SO_4 1+1 to hide the titanium oxide
- Titrate with EDTA 0.03 mol/l until turning to straw yellow - note Y
- The solution will be used to Al_2O_3 dosage

The expression of results is done according to the formula
% Fe_2O_3 = V x factor EDTA / Fe_2O_3
with V = volume in ml

2.3.3. Determination of MgO-Al_2O_3

- Take the solution used for the dosage of Fe_2O_3 - cool it
- Add 5 ml of acetic acid
- Add the pH to 3.05 ± 0.05 without exceeding 3.1 if not to repeat the analysis
- Bring to the boil
- Add 3 drops of copper complexonate and ten (10) drops of PAN
- Titrate with EDTA 0.03 mol/l by keeping boiling until turning to yellow - continue for 1 minute. Note V.

The expression of results is done according to the formula
% Al_2O_3 = V x factor Al_2O_3

2.3.4. Determination of other elements

The determination of other elements is performed in the same way.

3. RESULTS AND INTERPRETATION

The experiments performed provide raw results in general and will be, in the case of chemical characteristics, subject to a variety of interpretations.

3.1. Results of samples description

In general, the samples studied are translucent to slightly transparent, with sub-rounded, glassy luster inclusions (probably alkali feldspar).

The color may be bluish-green, greenish blue to brownish, pinkish, or blue lavender in natural light.

Note that their usually greenish color (Figure 7) in daylight turns into reddish in yellow light (Figure 8).

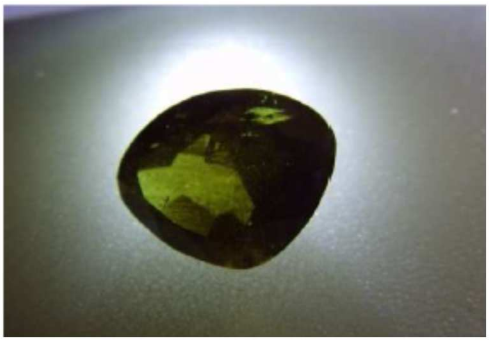

Figure 7: Photography in daylight

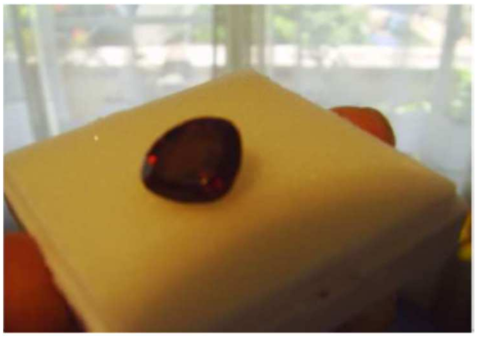

Figure 8: Photography in yellow light

3.2. Physical characteristics

Tenacity

We have not found breaking when a sample is dropped from a height of 1.50m on a tile floor.

Hardness

In trying to scratch each sample with the tip of a knife, we see that the mineral is not scratched by the metal. On the Mohs scale, the hardness appears to be between 6.5 and 7.

Refractive index

We are facing a problem of non homogeneity. The refractive index found on the classic refractometer varies from 1.665 to 1.670. We did not get more accurate data. A cons-analysis performed by the Presidium Duo Tester device gives values of reflective index between 34 and 36.

Density

We are also facing a problem of non homogeneity. The density (specific gravity) found on the density meter ranges from 3.35 to 3.84 depending on the samples.

3.3. Chemical Characteristics

Table 1 summarizes the results of chemical analyses. The results expressed in volume are written down as a percentage, and then we proceed to conventional calculations of the structural formula.

Table 1: Results of chemical analyses

Oxide	Moles Wt oxide	Grams oxide	Wt %	Moles oxide	Moles Cation	Moles Oxygen	Nb cation
SiO_2	60.089	42.543	57.26	0.953	0.953	1.906	2.05
Al_2O_3	101.96	9.8195	13.22	0.130	0.259	0.389	0.56
TiO_2	79.899	0.4794	0.65	0.008	0.008	0.016	0.02
Fe_2O_3	159.69	6.9923	9.41	0.059	0.118	0.177	0.25
FeO	71.85	1.5784	2.12	0.030	0.030	0.030	0.06

MgO	40.3	0.0000806	0.00	0.000	0.000	0.000	0.00
MnO	70.94	2.8375	3.82	0.054	0.054	0.054	0.12
CaO	56.08	0.00084	0.00	0.000	0.000	0.000	0.00
Na_2O	61.98	10.0431	13.52	0.218	0.436	0.218	0.94
K_2O	94.204	0.0000942	0.00	0.000	0.000	0.000	0.00
Total		74.2942	100			2.789	4.00

Additional analyses show the following chromium oxide and cobalt oxide contents:
Cr_2O_3 = 1.5959g/mol; wt = 1.05%
CoO = 0.001498g/mol; wt = 0.0002%
Co_2O_3 = 0.003317g/mol; wt = 0.0002%
Co_3O_4 = 0.004816g/mol; wt = 0.0002%

In Table 1, it should be noted that the calculated values are not accurate, probably due to analytical shortcomings. Note that the sum of moles of oxygen (column 7) of around 2.789 is false for this mineral. To get the number of cation (column 8), corrections are made, simply multiply each value (of column 6) by six (calculation based on six oxygen for the pyroxene) and divide it by the sum of oxygen (column 7).

4. DISCUSSION AND CONCLUSION

The first results obtained from the various characterizations carried out allowed us to advance a first conclusion.

The samples analyzed, usually of green-blue color, are sub-rounded and gem-shaped. The physical characteristics (density/specific gravity, hardness, refractive index) are similar to those of jadeite family minerals.

From a chemical standpoint, traces of chromium, titanium, and cobalt were also found. In addition to iron and manganese in significant quantity, the presence of cations derived from certain transition metals (Cr^{3+}, Ti^{3+}, Co^{3+}, etc.) in small quantities would be responsible for allochromatic colorations of our samples. In the literature, it is believed that the iron is responsible for the green color, while the manganese gives the pinkish color.

The structural formula corresponding to the above analysis is: $Na_{0.94-1}(Al_{0.56}Fe^{3+}_{0.44})\ Si_{2-2.05}O_6$, with traces of chromium, titanium and cobalt. It is compatible with the ideal chemical formula of family jadeite minerals: $Na(Al, Fe^{3+})\ Si_2O_6$.

This is therefore a gem-shaped pyroxene of inosilicates category, blue-green, rich in manganese, of a composition close to jadeite and which is equated with jades. Its main feature is its ability to change in color depending on the type of light. One wonders if the notable presence of manganese is responsible for this color change when the mineral is exposed to light to another. In any case, it is universally accepted that the natural presence of impurities of transition elements would be the cause of this spectacular optical effect.

In our opinion, it is therefore a pyroxene of jadeite family not yet listed in the literature. Now the fun idea to propose the name "ranoarivonite" to this type of gem-shaped iron-manganese jadeite is suggested.

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