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Comparison of Some Physicochemical Characterization of Columbite and Tantalite Samples from Different Locations in Nigeria

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Abstract

A detailed physicochemical characterization of columbite and tantalite samples from different locations in Nigeria has been undertaken. Parameters such as moisture content, loss of mass on ignition, pH, and the specific gravity of columbite and tantalite samples from different locations were determined and compared. The results showed that the moisture content of columbite samples obtained from Kwara and Plateau States are 1.0 and 0.53 %, respectively, while the percentage of moisture content of tantalite samples obtained from Kwara, Kogi, Kaduna, and Nasarawa States are 0.37, 0.30, 0.67 and 1.00 %, respectively. The percentage loss of mass on ignition of columbite samples obtained from Kwara and Plateau States and tantalite samples from Kwara, Kogi, Kaduna, and Nasarawa States are 6.1, 3.6, 7.7, 2.4, 4.4 and 4.3 %, respectively. Values of 2.40, 3.76, 3.65, 3.37, 2.07 and 1.96 were obtained as the specific gravities of columbite samples obtained from Kwara and Plateau States and tantalite samples from Kwara, Kogi, Kaduna, and Nasarawa States, respectively, and finally, the mean pH for each of columbite and tantalite samples was approximately 7.6.

Keywords: columbite, tantalite, moisture content, loss of mass on ignition, pH and specific gravity

INTRODUCTION

Columbite is the most widespread niobium mineral and makes for an important ore of the industrially useful metal [1]. Columbite, also called niobite, niobite-tantalite and columbate has a chemical formula $(Fe, Mn, Mg)(Nb, Ta)_2O_6$ [2]. It is a black mineral [3] group that is an ore of niobium and tantalum. It has a submetallic luster and a high specific gravity and is a niobate of iron and manganese, containing tantalate of iron while tantalite $(Fe, Mn)(Ta, Nb)_2O_6$ is the most widespread tantalum mineral and also makes for an important ore of the industrially useful metal [4]. It is a mineral that is close to columbite, the two minerals of this series have similar properties since they have the same structure and similar chemistries. Columbite has the same composition and crystal symmetry (orthorhombic) as tantalite. In fact, the two are often grouped together as a semi-singular mineral series called columbite-tantalite or coltan in many mineral guides. However, tantalite has a much greater specific gravity than columbite, more than 8.0 compared to columbite's 5.2 [5, 6] and columbite is the more niobium rich end member while tantalite is the more tantalum rich end member [4, 7]. Other properties that vary slightly are colour, transparency and streak.

Extensive columbite (niobium ore) and tantalite (tantalum ore) reserves are found in Canada, Brazil, Nigeria, Zaire and Russia [8, 9]. In Nigeria, columbite samples are located in Kwara, Kaduna, Bauchi (Bauchi Plateau), Plateau (Bassa, Jos East, Jos South, Jos North or Riyom), Kano, Kebbi, Gombe, Abuja, Nassarawa and River States [10] while tantalite samples are located in Kaduna (Abu hill, Gerti station or Tare Nandu), Kwara (Oro, Oke-Onig-

bin and Lema), Plateau, Kebbi, Nassarawa (Udegi, Kokona or Wamba-denga), Kogi (Mopa, Isanlu Isa, Ejuku or Takete), Osun (Osogbo), Ekiti, Cross River, Oyo and Abuja (Kusaki, Bize or Takwashera) [11].

This present investigation was therefore aimed at the physicochemical characterization and comparison of samples of columbite and tantalite from six different locations in Nigeria and to investigate whether the geographical locations of these minerals have an effect on the physicochemical parameters of this ore.

EXPERIMENTAL

Material

Columbite ore samples were obtained from Plateau (Bassa) and Kwara (Daba-Lema) States while tantalite samples were obtained from Kaduna (Geri Station), Nasarawa (Odegi), Kwara (Daba-Lema) and Kogi (Iya-Merin) States.

Physicochemical characterization

Some physicochemical parameters investigated include moisture content, loss of mass on ignition, pH and specific gravity.

Loss of mass on ignition determination. Weighed crucible with 1 g of columbite/tantalite sample was put inside a muffle furnace (Lindberg, model 51849) and roasted at high temperature of about 600 °C for about 2–3 h. After roasting, the sample was withdrawn from the furnace and allowed to cool in a desiccator. The cooled product was then reweighed.

The difference in mass represents the loss of mass on ignition which is equivalent to the mass of organic present in the mineral. The process was carried out in triplicate.

Moisture content determination. 1 g of columbite/tantalite sample was weighed and put in a crucible. This was then put inside an oven (Gallenkamp, model OV-330) and heated to a temperature of 105 °C for 5 h. After heating, the sample was withdrawn and quickly transferred into a desiccator in order to prevent further moisture absorption from the atmosphere. The cooled product was then reweighed.

The difference in mass gave the mass of moisture content of the mineral sample.

pH determination. The pH of 10 g suspension of columbite/tantalite in 30 mL distilled water was measured by the use of a pHep® HANNA pH meter. The measurement was monitored daily for two weeks.

Specific gravity determination. 10 g of oven dried columbite/tantalite sample was put inside a pycnometer followed by the addition of 30 mL distilled water and the pycnometer stoppered. The mixture was soaked for 30 min and bubble formation was prevented. The same procedure was performed using the same pycnometer containing distilled water. The specific gravity of the sample (G_s) is then determined thus [12]:

$$G_s = W_o/(W_o + (W_A - W_B)) \quad (1)$$

where W_o is mass of sample of oven dried columbite/tantalite, W_A is mass of pycnometer filled with water, W_B is mass of pycnometer filled with water and oven dried columbite/tantalite samples.

RESULTS AND DISCUSSION

Moisture content

A graphical representation of the percentage of moisture content of the different columbite and tantalite samples from different locations in Nigeria is shown in a bar chart in Fig. 1.

Figure 1 shows that the percentage of moisture content of columbite samples obtained from Kwara and Plateau States are 1.0 and 0.53 %, respectively, while the percentage of moisture content of tantalite samples obtained from Kwara, Kogi, Kaduna, and Nasarawa States are 0.37, 0.30, 0.67 and 1.00 %, respectively. It is also evident that the percentage of moisture content of columbite and tantalite mineral ore samples is very low ranging from 0.3 to 1.0 %.

The result showed that columbite sample obtained from Kwara State has greater moisture content as compared to columbite sample from Plateau State. The order of moisture content for tantalite samples in decreasing order of states are: Nasarawa > Kaduna > Kogi > Kwara with tantalite sample obtained from Nasarawa having the highest

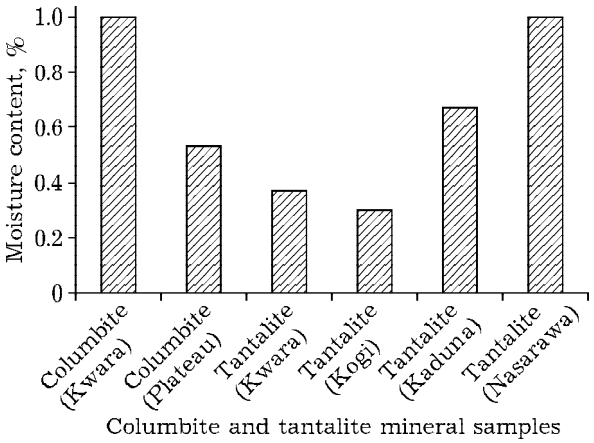

Fig. 1. Bar chart representation of the percentage of moisture content of columbite and tantalite samples from different location in Nigeria.

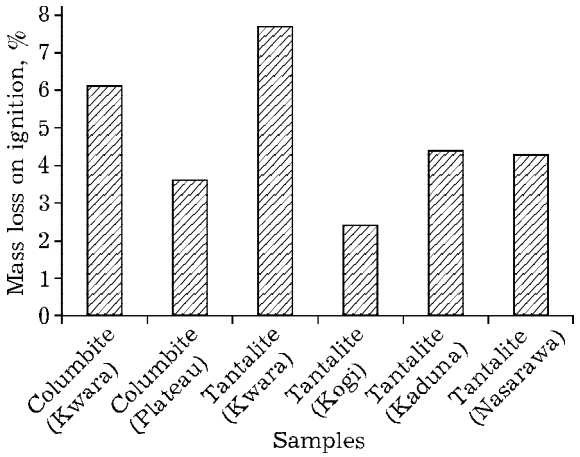

Fig. 2. Bar chart representation of the percentage of loss of mass on ignition of columbite and tantalite samples from different location in Nigeria.

percentage of moisture content. The difference in the percentage of moisture content of various columbite and tantalite samples may be attributed to difference in the geographical location of these samples.

It is obvious that columbite sample from Nasarawa State and tantalite sample from Kwara State have the same percentage of moisture content. Both mineral ores also have the highest percentage of moisture contents as compared to all other mineral ores.

Loss of mass on ignition

A graphical representation of the percentage loss of mass on ignition of the different columbite and tantalite samples from different locations in Nigeria is shown in a bar chart in Fig. 2.

Figure 2 shows that the percentage loss of mass on ignition of columbite samples obtained from Kwara and Plateau States are 6.1 and 3.6 %, respectively, while the percentage loss of mass on ignition of tantalite samples obtained from Kwara, Kogi, Kaduna, and Nasarawa States are 7.7, 2.4, 4.4 and 4.3 %, respectively.

The loss of mass could be accounted for by the presence of volatile or organic/decayed substances. The result showed that columbite sample obtained from Plateau State has lesser volatile/organic compounds as compared to columbite sample from Kwara State. The order of loss of mass on ignition for tantalite samples in decreasing order of states is: Kwara > Kaduna > Nasarawa > Kogi with tantalite sample obtained from Kogi State having the least volatile/organic compounds. The difference in the percentage of loss of mass on ignition of various columbite and tantalite samples may likewise be attributed to difference in the geographical location of these samples.

It is also evident from Fig. 2 that columbite and tantalite samples from Kwara State have the highest content of volatile/organic compounds as compared to all other mineral samples while tantalite samples obtained from Kaduna and Nasarawa State have virtually the same result for loss of mass on ignition determination.

Specific gravity

A graphical representation of the specific gravities of columbite and tantalite samples from different locations in Nigeria is shown in a bar chart in Fig. 3.

Figure 3 shows that the specific gravities of columbite samples obtained from Kwara and Plateau States are 2.40 and 3.76, respectively, while the specific gravities of tantalite samples obtained from Kwara, Kogi, Kaduna, and Nasarawa States are 3.65, 3.37, 2.07 and 1.96, respectively.

Columbite obtained from Plateau tends to be a better columbite ore in terms of specific gravity as compared to columbite obtained from Kwara while tantalite sample from Kwara State tends to be a better tantalite ore in terms of specific gravity compared to tantalite samples from Kogi, Kaduna and Nasarawa States.

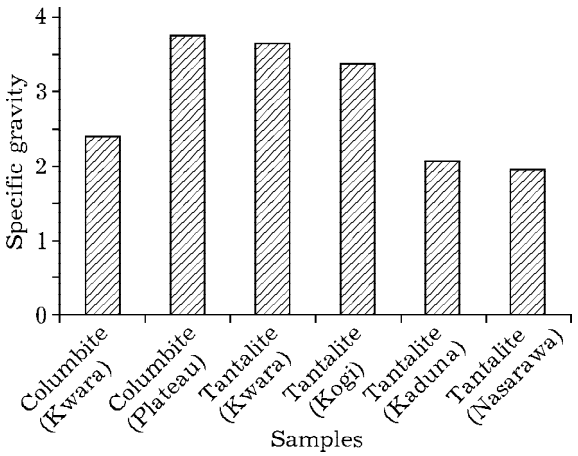

Fig. 3. Bar chart representation of the specific gravity of columbite and tantalite samples from different locations in Nigeria.

Figure 3 also shows that the specific gravities of columbite and tantalite mineral ores overlap. It is therefore evident that the two mineral ores (columbite and tantalite) are slightly difficult to distinguish by the use of specific gravity determination as the geographical locations of these minerals ores have significant effects on the specific gravity of these ores.

pH

A graph of pH against number of days in Fig. 4 showed an initial increase in pH measurement of columbite and tantalite samples between day 1 and day 2 after which the pH appears to be constant from day 4 to day 7. The constant pH could be attributed to total equilibration of the columbite and tantalite samples in the water suspension.

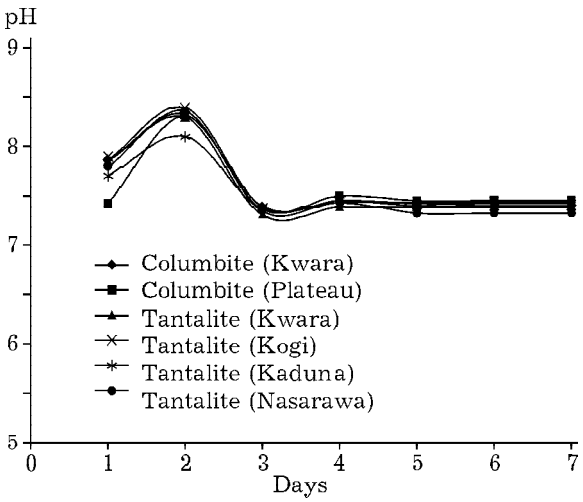

Fig. 4. pH *versus* days.

The pH measurement of columbite samples from Kwara and Plateau States are 7.43 and 7.45, respectively, while pH measurement of tantalite samples from Kwara, Kogi, Kaduna and Nasarawa are 7.39, 7.40, 7.42 and 7.32, respectively.

The mean pH for each of columbite and tantalite samples is approximately 7.6. This value suggests that the surfaces of columbite and tantalite are slightly basic. This is also in support of the predominant chemical form of columbite and tantalite, which is oxide.

CONCLUSION

In the present study, the physicochemical characterization of columbite and tantalite from different locations in Nigeria was studied. It was found that columbite sample obtained from Kwara State has greater moisture content as compared to columbite sample from Plateau State while tantalite sample obtained from Nasarawa has the highest percentage of moisture content, as compared to other tantalite samples. The result also showed that columbite sample obtained from Plateau State has lesser volatile/organic compounds as compared to columbite sample from Kwara State with tantalite sample obtained from Kogi State having the least content of volatile/organic compounds among the various tantalites. On specific gravity determination, columbite obtained from Plateau tends to be a better columbite ore in terms of specific gravity as compared to columbite obtained from Kwara while tantalite sample from Kwara State tends to be a better tantalite ore in terms of specific gravity, compared to tantalite samples from Kogi, Kaduna and Nasarawa states. These differences may be attributed to difference in the geographical location of these samples. The pH of these samples also suggests that the surface of columbite and tantalite from different locations in Nigeria is slightly basic.

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