The Proposal of Tungsten Ores Processing in Rwanda

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Abstract

Tungsten is one of the rare elements occurring in Earth. Its applicability and request for it causes that the production of this metal is very beneficial. One of the biggest deposits of this metal ores in the world is located in African country of Rwanda. Due to the lack of appropriate technology and lack of investments the current way of producing this valuable metal in this country causes that much of tungsten is wasted as well the production is slow and the results are not appropriate. That is why an attempt to propose an adequate processing way for this deposit was done and is presented in this paper. Authors performed several tests on the ore originating from Rwanda, including its mineralogical composition and tests performed by means of laboratory shaking table. The results are promising and the further tests, including other methods of beneficiation are planned, like second shaking table stage and flotation.

Keywords: *tungsten, rare earth elements, gravity separation, shaking table, recovery, yield*

1. Introduction

Tungsten is a hard, rare and essential metal in many applications whether commercial or industrial. The alloys of tungsten are extensively used to make so many different things, such as incandescent light bulb filaments, electrodes in welding, superalloys and radiation shielding, to name a few. It is much used in several military applications due to its hardness and density. This made tungsten one of the strategic metals in the world [Jarosiński and Madejska, 2016; Jarosiński et al., 2016; Leal-Ayala et al., 2015].

Considering geography of tungsten occurring, Rwanda is one of the top producers of tungsten globally, its concentrate counted 830 000 Mg in 2018 [USGS U.S geological survey, 2019]. Still, it is processed mostly in artisanal and small-scale mining ways which means that most mineral processing in Rwanda involves manual techniques, particularly without mechanical ones. It is known that depending on the style of mineralization, these traditional beneficiating techniques are likely to be inefficient and may lead to loss of high amount of ore particles of economic interest to the tailings. Tungsten concentrates from Rwanda are not upgraded at a mine site, they have to be transported miles away for proper and profitable processes. So, it is due to inefficient processing methods, insufficient mount of processing plants as well lack of controlled comminution processes that some useful minerals are simply lost. Moreover, the distance transportation of materials that still need to be upgraded from their place of origin to another one for additional further processes causes also additional economic costs for the mining industry in Rwanda. Consequently, tungsten processing plants in Rwanda produce concentrates of grades lower than the ones achieved in 2013 and it is very important for Rwanda to introduce more modern and more efficient methods in the process.

2. Properties and applications of tungsten

Tungsten hardness and wear resistance make it valued. It has its highest melting point at the temperature of 3422°C and its density of 19.25 g/cm³. Moreover, it is among the substantial metals. More detailed tungsten properties are listed in Table 1.

Tungsten is used in many technological applications, due to its exceptional physical and chemical properties. Its main usage is found in the manufacture of cemented carbides which is the main consumer of tungsten today.

The other usage of tungsten is that it is used as the alloying element in the iron and steel industry. Also, it is found in many metal products, such as lighting filaments, electrodes, rods, electrical and electronic contacts, wires, sheets etc. Figure 2 presents the global consumption of tungsten in main countries of the World and in Europe.

The prime economic minerals of tungsten are scheelite, ferberite, hübnerite, and wolframite, the content of tungsten in the earth's crust is 0.007%. Tungsten grade in feed should be at least 0.3 to 1% concentration so the mining is beneficial [https://www.itia.info/about-tungsten.html]. There are more than 20 tungsten bearing mineral but only wolframite and scheelite are essential for industrial use. Their main features are listed in Table 2.

World tungsten resources are geographically widespread. Even though China has been topping other countries, in terms of tungsten resources and reserves, there are other countries with significant concentration including, Russia, Canada, US, Bolivia, Vietnam, Portugal, Spain, Austria, Rwanda, UK.

The production of tungsten concentrates in Rwanda and other countries in period 2017–2018 is shown in Table as well on Figure 2. The variation of production of tungsten in Rwanda for the period 2011–2018 is shown on Figure 4.

Tab. 1. Tungsten properties [https://www.itia.info/about-tungsten.html]
Tab. 1. Właściwości wolframu [https://www.itia.info/about-tungsten.html]

Atomic Mass	183.84
Atomic Radius (Metallic)	137 Pm
Boiling Point	5700±200°C
Coefficient of Thermal Expansion	4.32-4.68×10-6•K-1 (298 K)
Crystal Structure	Body-Centered Cubic A2
Density	19.25 G/Cm3 (298 K)
Electron Configuration	[Xe] $4f^{14}$ $5d^4$ $6s^2$
Electrical Resistivity	5.28 μω•Cm
Enthalpy Of Fusion	46 Kj•Mol-1
Lattice Parameter	A=3.16524 Å (298 K)
Magnetic Ordering	Paramagnetic
Melting Point	3422°C
Modulus Of Elasticity	390-410 Gpa (298 K)
Specific Heat Capacity	135 J•Kg-1•K-1 (298 K)
Thermal Conductivity	1.75 •W•Cm-1 •K-1(298 K)
Vapor Pressure (2000°C)	8.15×10^{-8} Pa

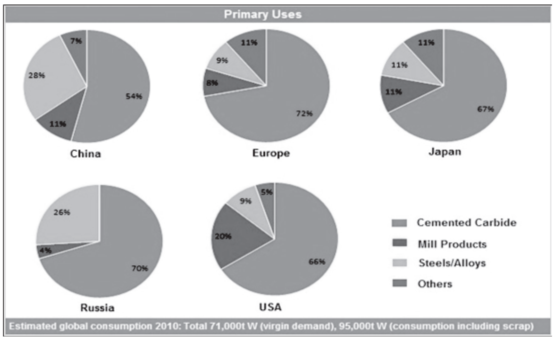

Fig. 1. Estimated global consumption of tungsten in 2010, source: International tungsten industry association [https://www.itia.info/about-tungsten.html]
Rys. 1. Szacowana konsumpcja światowa wolframu w roku 2010; źródło: International tungsten industry association [https://www.itia.info/about-tungsten.html]

Tab. 2. Tungsten bearing economical minerals [Pitfield et al., 2011]
Tab. 2. Minerały wolframu [Pitfield et al., 2011]

Name	Formula	Tungsten content (WO_3 %)	Specific gravity (g/cm^3)	Appearance (colour and lustre)	Crystal structure
Wolframite	$(Fe,Mn)WO_4$	76.5	7.1-7.5	Dark grey to black, sub-metallic to metallic	Monoclinic
Ferberite	$FeWO_4$	76.3	7.5	Black, sub-metallic to metallic	Monoclinic
Hubnerite	$MnWO_4$	76.6	7.2-7.3	Red-brown to black, sub-metallic to adamantine	Monoclinic
Scheelite	$CaWO_4$	80.6	5.4-6.1	Pale yellow to orange, green to dark brown, pinkish-tan, dark blue to black, white or colourless, vitre- ous or resinous	Tetragonal

Tab. 3. Tungsten concentrates production worldwide in thousands of kg, years 2018−2019 [USGS U.S geological survey, 2020]
Tab. 3. Produkcja koncentratów wolframu na świecie w 1000 kg, lata 2018−2019 [USGS U.S geological survey, 2020]

COUNTRY	Production [thousands of kg]	
	2018	2019
United States	-	-
Austria	936	940
Bolivia	1,370	1,200
China	65000	70000
Korea, North	1,410	1,100
Mongolia	1,940	1,900
Portugal	715	700
Russia	1500	1500
Rwanda	920	1,100
Spain	750	500
United Kingdom	900	-
Vietnam	4800	4800
Other Contries	900	900
World (Total)	81100	85000

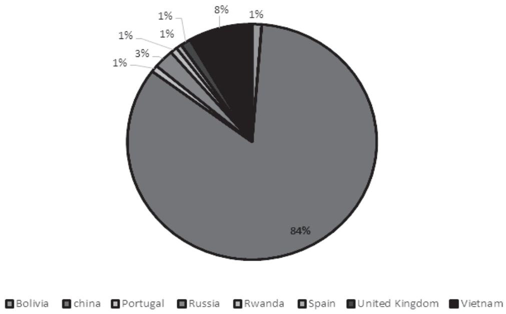

Fig. 2. Tungsten Production Worldwide in 2018 [USGS U.S geological survey, 2019)
Rys. 2. Produkcja wolframu na świecie w roku 2018 [USGS U.S geological survey, 2019]

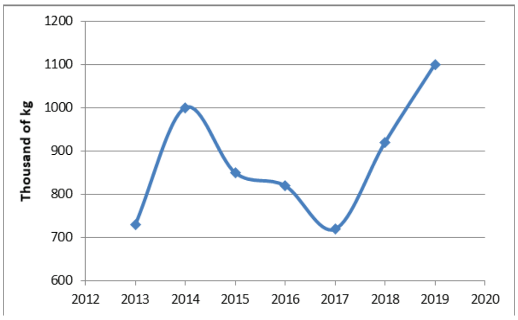

Fig. 3. Variation of Rwanda Tungsten Concentrate Production From 2011–2018 [USGS U.S geological survey, 2015, 2016, 2017, 2018, 2019, 2020]
Rys. 3. Zmienność produkcji koncentratu wolframu w Rwandzie od 2011–2018 (USGS U.S geological survey, 2015, 2016, 2017, 2018, 2019, 2020)

Today, the number of applications of tungsten is increasing very fast and the industrial demand for it increases. Hence, the request for low-grade complex ores is increasing and this leads to the complexity of its beneficiation.

3. Tungsten processing in Rwanda

Artisanal processing is a way of beneficiation that is made in a traditional or non-mechanized way. In Rwanda, it includes panning, handpicking, ground sluicing, air classification, manual magnetic separation.

How exactly these processes are being done can be found in [Heizmann and Liebetrau, 2017] with step by step guide, demonstration figures and a detailed comparison of both artisanal and mechanical processing in Rwanda, not only for wolframite but for cassiterite as well. However, the main techniques of processing used there are listed below.

- Panning: an artisanal method of separation which sorts particles by their specific gravity. It is made of ponds filled halfway with water, with 2 m * 2 m and 6 m of size and depth respectively.
- Hand-picking: it is used to pick coarse particles; it is done by a miner who is familiar with that type of mineral and knows very well the physical properties of the minerals. Every grain is sorted manually.
- Ground sluicing: density sorting method, but its negative side is that it requires high amount of water.
- Air classification/tap and blow/winnowing: after the drying of the concentrate, artisanal air classification. Applicability of this technique depends on the grain size of the concentrate. It is only suitable for relatively low grain-sized pre-concentrates. light particles accumulate at the edge of the material cone and can be carefully blown away (blow) by the worker.
- Artisanal magnetic separation: a manual magnet separation for the final processing step.

In recent years, a few of Rwanda mining companies introduced mechanical equipment to add more value and increase their production, including crushers, spirals and shaking tables, but still a lot is to be improved [Wills and Finch, 2015; Gupta and Yan, 2016, Sutaone et al., 2000]. Shaking tables are the most used mechanical beneficiation technique used in Rwanda. The typical flowsheet for tungsten processing is presented on Figure 4.

4. Experiment

4.1 Description

The sample was collected from Muyira Cell of Manihira Sector, Rutsiro District. Minerals in this block are handpicked from underground hydrothermal quartz veins which were hosted in black shales. The sample consists of brown material (clayish) with blocks of quartz and black crystals of wolframite. Often, the quartz coating of iron oxide could be visible in quartz. The brownish clay material silicates, iron hydroxide and sulfides (weathered or partly altered) could be visible too. Scheelite is also present in small particles form enclosed in quartz.

4.2 Sample characteristics – XRF analysis

The small representative amount of sample of granulation below 0.2 mm was prepared by means of mixing and XRF analysis. These analyses were conducted and repeated 3 times for ensuring sufficient accuracy. The average result obtained

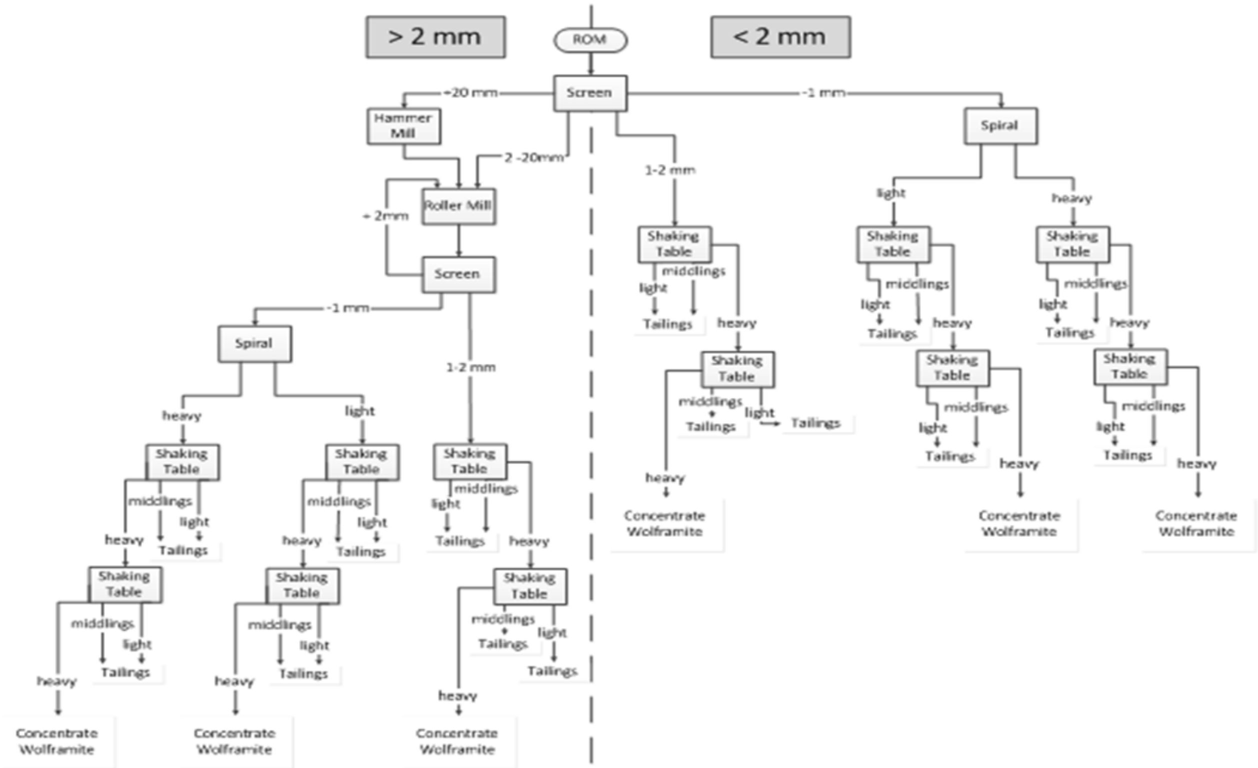

Fig. 4. Flowsheet of the mechanical processing scheme of wolframite beneficiation [Heizmann and Liebetrau, 2017]
Rys. 4. Schemat ideowy przeróbki mechanicznej wolframu [Heizmann and Liebetrau, 2017]

Tab. 4. XRF analysis results of feed
Tab. 4. Wyniki analizy XRF dla nadawy

Product	Element	1	2	3	Average [%]
Feed	***Mn***	0.584	0.566	0.564	0.571
	Fe	11.640	11.557	11.863	11.687
	As	0.038	0.037	0.036	0.037
	W	23.735	23.291	24.000	23.675

showed an overall head grade of 23.675% WO_3, 11.687% Fe, 0.571% Mn and very low grade of arsenic of about 0.037%. Table 4 demonstrates all three repeated test results performed on the feed.

Ferberite ($FeWO_4$) and hübnerite ($MnWO_4$) are commonly the main wolframite minerals in such deposit types. The amount of manganese can be observed – average grade of 0.571%, but comparing to iron it is low amount – Fe content reaches in average to 11.687%.

Basing on the analysis, it is obvious to consider ferberite as the main tungsten mineral contained in the sample.

4.3 Sample preparation

The sample preparation aim was to get all particles in the feed of the preferred size. First, the sample material of a maximum of 31 mm size was put into screen, the material of size lower than 1 mm was removed and the remaining part was put into jaw crusher. Next, the material was transferred to a rod mill and then to screen. These stages were repeated continuously to get the expected particle size.

The sieving time was equal to 5 minutes. Each time the -0.2 mm mesh material was screened out and the remaining material was passed again through the laboratory rod mill or ball mill until the whole material was characterized with the size below 0.2 mm. The obtained products were well mixed and then were divided into 5 parts. Such representative samples were divided as well into parts, where 25% was dedicated to XRF analysis and the rest for sieve analysis.

The samples taken from screen analysis were examined under a binocular microscope. The mineralogical components were quartz with wolframite, mainly FeWO4 as well a significant amount of scheelite. The whole scheme of the sample preparation is shown on Figure 5.

5. Results and discussion

The results of sieve analysis are positioned in Table 5 and the particle size distribution is presented on Figure 6.

Table 6 describes the amount of W, Fe, As, Mn in each particle size fraction, being: -0.063; 0.063–0.1; 0.1–0.16 and 0.16–0.2 [mm]. The obtained results of XRF analysis showed

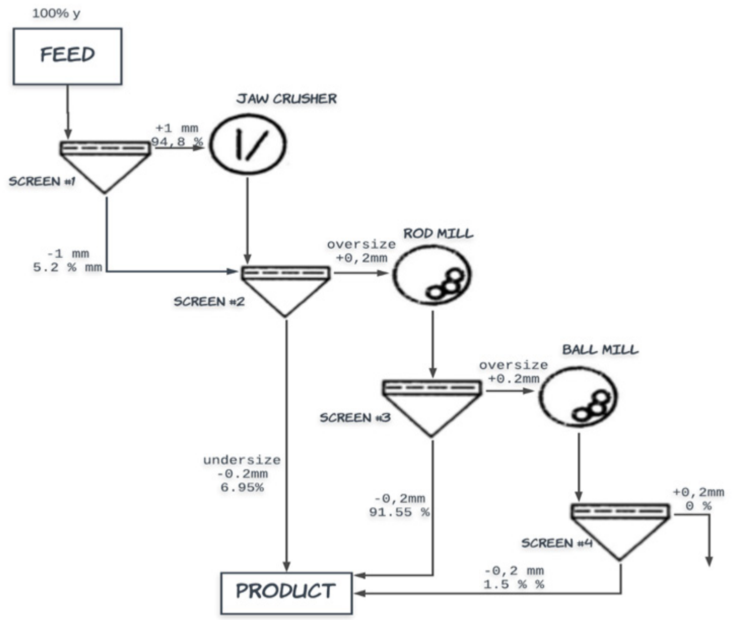

Fig. 5. Sample preparation flowsheet [source: own elaboration]
Rys. 5. Schemat przygotowania próbek [źródło: opracowanie własne]

Fig. 5. Sample preparation flowsheet [source: own elaboration]
Rys. 5. Schemat przygotowania próbek [źródło: opracowanie własne]

Sieve Range	Aperture Size [mm]	Yield [%]	Cummulative [%]	
			Undersize	Over Size
0.2-0.16	0.16	7.200	92.80	7.20
0.16-0.1	0.1	23.700	69.10	30.90
0.1-0.063	0.063	22.000	47.00	53.00
< 0.063	0	47.000	0.00	100.00

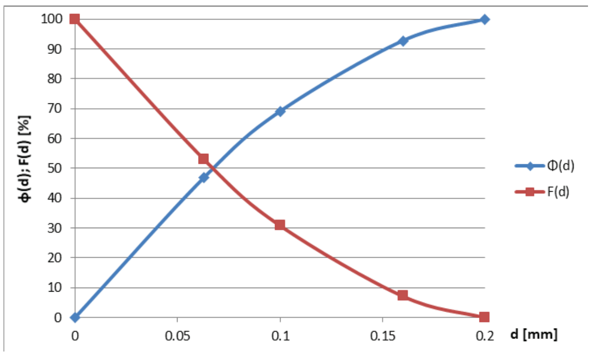

Fig. 6. Particle size distribution results after sample preparation [source: own elaboration]
Rys. 6. Wyniki składu ziarnowego po przygotowaniu próbki [źródło: opracowanie własne]

Tab. 6. Particle size fractions XRF analysis result [source: own elaboration]
Tab. 6. Wyniki analizy XRF dla klas ziarnowych [źródło: opracowanie własne]

Particle Size Fraction [mm]	Yield [%]	The average amount of useful element in particle size fraction [%]			
		Mn	Fe	As	W
< 0.063	47.0	0.608	12.684	0.046	22.770
0.063 - 0.1	22.1	0.474	9.953	0.030	20.515
0.1 - 0.16	23.7	0.433	9.719	0.030	19.409
0.16 - 0.2	7.2	0.572	11.167	0.086	24.778

Tab. 7. The percentage difference between elements in raw feed and elements from the balance of particle size fractions [source: own elaboration]
Tab. 7. Różnice procentowe pomiędzy zawartością pierwiastków w nadawie oraz obliczoną z bilansu klas ziarnowych [źródło: opracowanie własne]

Element	The average amount of element in raw feed [%]	The average amount of element from the balance of particle size fractions [%]	The Percentage difference between raw feed and balance from particle size fractions [%]
Mn	0.571	0.534	6.497
Fe	11.687	11.269	3.576
As	0.037	0.042	10.892
W	23.675	21.62	8.682

Tab. 8. Yield of concentrate and tailings in each product [source: own elaboration]
Tab. 8. Wychód koncentratu oraz odpadów w każdym z produktów [źródło: opracowanie własne]

Products number	Yield [%]	
	Concentrate	Waste
1	64.116	35.884
2	64.706	35.294
3	61.136	38.864
4	60.694	39.306
5	61.154	38.846
Average	62.361	37.639

Tab. 9. Average element content in beneficiation products [source: own elaboration]
Tab. 9. Średnia zawartość pierwiastków w produktach wzbogacania [źródło: opracowanie własne]

Product	Yield [%]	Element	Average Amount Of Element [%]
Concentrate	62.361	Mn	0.743
		Fe	12.737
		As	0.134
		W	29.133
Waste	37.639	Mn	0.296
		Fe	8.938
		As	0.089
		W	11.117

Tab. 10. Recovery of tungsten in each separation test and average from all tests [source: own elaboration]
Tab. 10. Uzysk wolframu w produktach wzbogacania oraz uzysk średni [źródło: opracowanie własne]

Test	Recovery Value [%]	
	Concentrate - ε_w	Waste - η_w
1	80.147	19.853
2	80.160	19.840
3	83.556	16.444
4	82.212	17.788
5	80.801	19.199
Average from all tests	81.279	18.721

that the smallest amount of W occurred in a fraction 0.1–0.16 [mm] and the highest amount of W was found in fraction 0.16–0.2 [mm]. Considering the percentage difference between each analyzed element in raw feed and te balance of particle size fractions is visible that the biggest difference occurred for As (around 10%). In case of W this difference was equal to 8%. The results are presented in Table 7.

Next step were tests performed on a laboratory shaking table. The study was completed using 5 test products, with different masses and all of them showed similar characteristics with slight differences. For example, the difference of tungsten recovery in concentrate was equal to only 0.013% and the biggest observed difference was equal only to about 2%, which is acceptable. The same observations can be noticed for other investigated elements.

The dried weight of each test product was 464 g, 408 g, 440 g, 432.5 g, 450.5 g corresponding with 1st product, 2nd, 3rd, 4th, and 5th respectively. Table 8. shows the mass of the concentrate and tailings in each product.

The average amount of tungsten in the concentrate was equal to 29.13%, while the amount of it in tailings was equal to 11.12%. This shows that there is necessity to perform additional processes to recover W from the tailings. Table 9 il-

Tab. 11. Recovery of iron in each separation test and average from all tests [source: own elaboration]
Tab. 11. Uzysk żelaza w produktach wzbogacania oraz uzysk średni [źródło: opracowanie własne]

Test	Recovery Value [%]	
	Concentrate – ε_i	**Waste – η_i**
1	73.274	26.726
2	70.480	29.520
3	69.416	30.584
4	68.074	31.926
5	69.883	30.117
Average from all tests	70.247	29.753

Tab. 12. Recovery of manganese in each separation test and average from all tests [source: own elaboration]
Tab. 12. Uzysk manganu w produktach wzbogacania oraz uzysk średni [źródło: opracowanie własne]

Test	Recovery Value [%]	
	Concentrate – ε_m	**Waste – η_m**
1	79.248	20.752
2	78.926	21.074
3	82.808	17.192
4	81.702	18.298
5	80.648	19.352
Average from all tests	80.606	19.394

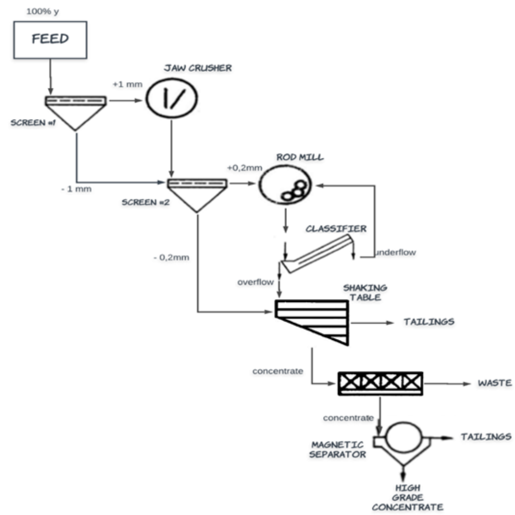

Fig. 7. Wolframite processing flowsheet proposal [source: own elaboration]
Rys. 7. Propozycja schematu technologicznego przeróbki wolframitu [źródło: opracowanie własne]

lustrate not only the results for W, but also for As, Fe and Mn. Considering that the yield of concentrate was equal to 62.36% (in average) and yield of tailings to 37.63% (in average) it can be said that the results are promising but the process requires additional stage or introduction of other processes, like flotation [Mohammadnejad et al., 2018] or magnetic separation [Lu et al., 2016]. In further steps, hydrometallurgy or pyrometallurgy can be applied to the process of producing tungsten products [Singh Gaur, 2006]. The most important results are shown in Tables 9–12.

Basing on the obtained knowledge, the Authors propose to apply the tungsten processing scheme, like is presented on Figure 7. Although, it looks correctly this proposal needs to be verified empirically, which will be the next target to perform. The obtained results can be applied in Rwanda to process wolframite ores. Furthermore, the other products contained in the ore should be also the point of interest, including Fe, in particular.

6. Conclusions

The results of the work show that the grain class 0.16–0.2 mm contained the highest amount of useful minerals. So, it is necessary to control the grinding stage to not excess the production of the finest material, because it usually occurs in tailings. Gravity concentration (by means of shaking table) is undoubtedly the best method of tungsten beneficiation since it seemed efficient and showed a good recovery level. However, it is important to add some supportive beneficiation stages as another step of gravity separation or floatation to recover, particularly very fine particles. Also, the magnetic separation can be useful to fully separate useful metals, like iron.

Shaking table recovery results were equal to 80.15~83.56% of W; 69.42~73.00% of Fe and 78.93~82.81 of Mn. The highest recovery rate achieved in the test series was equal to about 83.56% which can be assumed as good. As it is not possible to achieve the recovery equal to 100% in practice, it can be increased by introduction of additional beneficiation stages as is mentioned above. Also, the control of grinding stages can add some percentage to the recovery rate.

The amount of the metals in tailings is significant in average, equal to about 20% of each considered element. Certainly, it is advised to do more research before adopting the idea to industrial conditions. The flowsheet used in the research work consisted only of one separation stage. This was caused by a limited time being a result of difficulties in obtaining the ore samples from Rwanda. However, the remaining proposed tests such as flotation and magnetic separation will be conducted in the near future. Also another step of gravity separation process related to wastes will be considered (cleaning shaking table process).

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Literatura – References

1. GUPTA A, YAN D.S., Introduction to Mineral Processing Design and Operation, Elsevier, 2016.
2. HEIZMANN J., LIEBETRAU M., Efficiency of Mineral Processing in Rwanda's Artisanal and Small-Scale Mining Sector Quantitative Comparison of Traditional Techniques and Basic Mechanized Procedures, Bundesanstalt für Geowissenschaften und Rohstoffe, Kigali, February 2017.
3. International Tungsten Industry Association, https://www.itia.info/about-tungsten.html
4. JAROSIŃSKI A., MADEJSKA M., Selected Issues of Mischmetal and Other Rare Earth Metal Obtaining, Journal of Polish Mineral Engineering Society, 37(1), pp. 249-256, 2016.
5. JAROSIŃSKI A., ŻELAZNY S., CHOLEWA M., Raw Materials and Possibilities of their obtaining in Poland, Journal of Polish Mineral Engineering Society, 37(1), pp. 233-240, 2016.
6. LEAL-AYALA D., PETAVRATZI E., ALLWOOD J.M., BROWN T., Mapping the Global Flow of Tungsten to Identify Key Material Efficiency and Supply Security Opportunities, Resources Conservation and Recycling, 103, pp. 19-28, 2015.
7. LU D., WANG Y., JIANG T., SUN W., HU Y., Study on Pre-Concentration Efficiency of Wolframite from Tungsten Ore Using Gravity and Magnetic Separations, Physicochemical Problems of Mineral Processing, 52(2), pp. 718-728, 2016.
8. MOHAMMADNEJAD S., NOAPARAST M., HOSSEINI S., AGHAZADEH S., MOUSAVINEZHAD S., HOSSEINI F., Physical Methods and Flotation Practice in the Beneficiation of a Low Grade Tungsten-Bearing Scheelite Ore, Mineral Processing of Non-Ferrous Metals, 59, pp. 6-15, 2018.
9. PITFIELD P., BROWN T., GUNN G., RAYNER D., British Geological Survey 'Tungsten' January 2011, www.MineralsUK.com, 2011.
10. SINGH GAUR R., Modern Hydrometallurgical Production Methods for Tungsten, JOM: the journal of the Minerals, Metals & Materials Society, 58(9), pp. 45-49, 2006.
11. SUTAONE A.T., GHOSH S.K., RAJU K.S., Physical Separation Processing of a Bulk Tintungsten Pre-Concentrate into its Individual Constituents for Commercial Applications, Developments in Mineral Processing, 13(C9), pp. 7-12, 2000.
12. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2015: U.S. Geological Survey, 199 p., https://doi.org/10.3133/70202434, pp. 174-176.
13. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2016: U.S. Geological Survey, 205 p., https://doi.org/10.3133/70202434, pp. 180-181.
14. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2017: U.S. Geological Survey, 206 p., https://doi.org/10.3133/70202434, pp. 180-181.
15. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2018: U.S. Geological Survey, 204 p., https://doi.org/10.3133/70202434, pp. 178-179.
16. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2019: U.S. Geological Survey, 200 p., https://doi.org/10.3133/70202434, pp. 178-179.
17. U.S. Geological Survey, 2019, Mineral Commodity Summaries 2020: U.S. Geological Survey, 204 p., https://doi.org/10.3133/70202434, pp. 178-179.
18. WILLS B.A., FINCH J.A., Mineral Processing Technology. An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Butterworth-Heinemann, 2015.

Propozycja układu przeróbki rud wolframu w Rwandzie

Wolfram jest jednym z pierwiastków rzadkich występujących na Ziemi. Jego zastosowania oraz zapotrzebowanie świata na ten produkt powodują, że produkcja tego metalu jest bardzo opłacalna. Jedno z największych złóż rudy tego metalu na świecie jest zlokalizowane w afrykańskim państwie, jakim jest Rwanda. Ze względu na brak odpowiedniej technologii oraz brak inwestycji obecny sposób produkcji tego cennego metalu w tym państwie powoduje, że duża ilość wolframu jest tracona, produkcja jest powolna, a wyniki nie są satysfakcjonujące. Dlatego przeprowadzono próbę zaproponowania odpowiedniego sposobu przeróbki tego złoża, która została zaprezentowana w tym artykule. Autorzy wykonali dużo ilość testów przeprowadzonych na rudzie sprowadzonej z Rwandy, włączając w to jej skład mineralogiczny, jak również testy laboratoryjne wzbogacania na stole koncentracyjnym. Wyniki są obiecujące a dalsze testy, włączając w to także inne metody wzbogacania są planowane do przeprowadzenia, biorąc pod uwagę drugi etap wzbogacania na stole koncentracyjnym czy flotację.

Słowa klucze: *wolfram, pierwiastki ziem rzadkich, wzbogacanie grawtacyjne, stół koncentracyjny, uzysk, wychód*