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Characterization of Balikesir Balya Lead-Zinc Ore and Determination of its Particle Shape Factor

Balıkesir Balya Kurşun-Çinko Cevherinin Karakterizasyonu ve Tane Şekil Faktörünün Belirlenmesiis

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Abstract
In this study, detailed characterization tests were carried out to determine the physical, chemical and mineralogical properties of lead-zinc ore samples from Balya district of Balikesir province. Moisture, density and particle size distribution analyzes for the determination of the physical properties; XRF and ICP-OES analyzes for the determination of their chemical properties; XRD, SEM, EDS, polished section studies for the determination of mineralogical properties and pH measurements of the samples were carried out. Within the scope of particle shape factor studies, the circularity, roundness and solidity values of the ore were determined. Although it was seen that the benefication of the ore by flotation method was appropriate based on the results obtained from the study, alternative benefication studies from the past to the present were also mentioned. It is expected that the results obtained from this study will shed light on the fact that more scientific research can be done on the recovery of lead and zinc content with known ore processing methods on Balıkesir Balya Pb-Zn ore samples and new methods can be tried.
Anahtar Kelimeler: Characterization, Lead, Particle Shape Factor, Zinc

Abstract
Bu çalışmada Balıkesir ili Balya ilçesi kurşun-çinko cevheri örneklerinin fiziksel, kimyasal ve mineralojik özelliklerinin belirlenmesi amacıyla detaylı karakterizasyon çalışmaları yapılmıştır. Numunelerin fiziksel özelliklerinin saptanması amacıyla nem, yoğunluk ve tane boyut dağılımı analizleri; kimyasal özelliklerinin saptanması amacıyla XRF ve ICP-OES analizleri; mineralojik özelliklerinin saptanması amacıyla XRD, SEM, EDS, parlak kesit çalışmaları ve pH ölçümleri gerçekleştirilmiştir. Tane şekil faktörü çalışmaları kapsamında cevherin dairesellik, yuvarlaklık ve sertlik değerleri belirlenmiştir. Çalışmadan elde edilen sonuçlara istinaden cevherin flotasyon yöntemi ile zenginleştirilmesinin uygun olduğu görülmüş olsa da, geçmişten günümüze kadar yapılan alternatif zenginleştirme çalışmalarına da değinilmiştir. Bu çalışmadan elde edilen sonuçların Balıkesir Balya Pb-Zn cevheri numuneleri üzerinde bilinen cevher işleme yöntemleriyle kurşun ve çinko içeriğinin geri kazanımı konusunda daha fazla bilimsel araştırma yapılabileceği ve yeni yöntemler denenebileceği hususunda ışık tutması beklenmektedir.
Keywords: *Çinko, Karakterizasyon, Kurşun, Tane Şekil Faktörü*

1. Introduction

Lead which is a dense, ductile, and malleable blue-gray metal that is highly resistant to corrosion; have been used for at least 5000 years, many of its ancient applications (in the construction of water pipes in the time of Ancient Egypt and Romans) remaining intact until today. Lead (Pb) is a metallic element with 207.19 g/mol nucleon number, 82 atomic number, 11.34 g/cm^3 density, 327°C melting point, 1749°C boiling point and 1.5 hardness. The main lead minerals, which are found more than 130 in nature, are galena, cerussite, anglesite, jamesonite, jordanite, bulangerite, pyromorphite, mimetite and vulfenite. Galena is the most abundant lead mineral in economically operated deposits and is usually found together with zinc, copper, silver, gold and iron minerals. The most important consumption areas of lead are battery manufacturing and underground communication cables' insulation with lead. Lead is also used in oxide dyes, cable sheating, lead tetraethyl and tetramethyl forms as octane adjusting compounds in gasoline, x-ray protection because of its transmission of radiation the least, and in the production of color television tubes (Bulut, 1991; Engin, 2002; Fidan, 2016; MTA,2021-1; USGS, 2021-1).

Zinc was first used by the Chinese and Romans in 2000 BC as an alloy material in making brass. In India, it is known that zinc was used as a metal in 1000-1300 AC and smelting was done for commercial purposes in the 14th century. The invention of the flotation method at the beginning of the 20th century provided an important technological development in the zinc industry. Zinc (Zn) is a bluish-light gray metal with 65.409 g/mol nucleon number, 30 atomic number, 7.14 g/cm^3 density, 419.53°C melting point, 907°C boiling point and 2.5 hardness. More than 50 minerals of zinc are known. The most important mineral that makes the greatest contribution to zinc production is sphalerite. In addition, other zinc minerals of commercial value are smithsonite, zincite, willemite, franklinite and hemimorphite. Zinc is one of the three most important metals after aluminum and copper among non-ferrous metals in terms of usage. Since it is chemically active and easily alloyed with other metals, zinc is used in the production of many alloys and compounds in the industry. Due to its strong electropositive properties, it is used to protect other metals, especially iron and steel products, against corrosion. There are five main areas where the produced zinc metal is consumed as the main product. These are galvanizing, diecast alloys, brass and bronze alloys, zinc oxide and rolled zinc alloys (DPT, 2001; Aykac, 2006; MTA, 2021-2; USGS, 2021-2).

Ore samples are characterized according to the amount of mineral/metal they contain, their behavior, particle sizes, structure and tissue properties. These properties are used to determine the liberation states of minerals and the most appropriate benefication method. Structural and tissual properties of minerals such as formation and particle size are the parameters that directly affect the degree of ease of the mineral extraction process and therefore the cost of the process, and it is at least as important as knowing the amount of precious mineral/metal in the ore. Knowing the amount of minerals with different structure-tissue characteristics is also important in terms of predicting the performance and product characteristics of the subsequent processes (Can and Celik, 2009-1; Can and Celik, 2009-2). Several studies were performed in order to characterize lead-zinc ore (Song et al., 1999; Martinez and Motto, 2000; Zhang et al., 2020; Bourourou et al., 2021). The benefication of lead-zinc ores is generally carried out by gravimetric methods or by flotation method. The benefication of sulphide ores is carried out entirely by flotation. It is possible to selectively acquire lead and zinc separately with high efficiency (Agacayak and Yilmaz, 2021; MTA; 2022). It is of great importance that the characterization is carried out correctly in line with the information that directly affects the choice of ore benefication method, such as the mineralogical structure of the ore, impurities and particle liberation size. In this study, detailed characterization studies were carried out in terms of physical, chemical and mineralogical properties of Balikesir Balya lead-zinc ore samples and the circularity, roundness and solidity values of the ore were determined within the scope of particle shape factor studies. It is expected that the results obtained will shed light on the scientific studies and the selection of the benefication method related to the ore in question.

2. Materials and Methodology

The basis of the study is the lead-zinc ore of Balya town of Balikesir province. The samples were obtained from Eczacıbaşı Esan IC Balya Lead-Zinc Plant. In the preparation of the samples for experimental studies, primarily representative samples were obtained by using cone-quartering apparatus and Riffle sample dividing apparatus. Jaw crusher was used as primary and secondary crusher. The samples, which were crushed below 2 mm, were ground in a ball mill by working in a closed circuit with a sieve. Agate mortar was used for elemental analyzes and density experiments. Moisture, density and particle size distribution analyses to determine the physical properties of the samples; ICP-OES and XRF analyses to determine chemical properties; XRD, SEM, EDS and polish section studies to determine mineralogical properties; and pH measurements were carried out.

2.1. Work Area

The basis of the study is the lead-zinc ore of Balya town of Balikesir province. Due to its geological structure, Balıkesir province is particularly rich in base metal mineralizations. Foremost among these is the Balya lead-zinc deposit which is known to have been operated occasionally since ancient times. Balya lead-zinc deposit is spread over an area of approximately 8km^2, which includes Balya town center and its surroundings. 3.260.000 tons of proved reserves were found in the deposit, with a grade of 7.2% Zn, 2.7% Pb and 0.3% Cu (MTA, 2019). In Figure 1, the location map of the Balikesir Balya lead-zinc ore work area is given.

Balya Lead-Zinc deposit is located within the borders of Balya District -49 km northwest of Balikesir city center-, at the junction of Balikesir-Canakkale, Balikesir-Gonen state highways in the Biga Peninsula of the Marmara Region. Balya Pb-Zn mineral deposit -which was also operated in ancient times- was operated during the Ottoman period (1839) and afterwards by foreign companies until 1939. Studies for the re-operation of the mines and wastes left over from these enterprises continued until 1997. There are Paleozoic, Mesozoic and Tertiary aged formations as extraneous blocks in the study area. In the geological studies, it was determined that there are mainly Permian aged (Balya Formation) allochthonous limestones. The bedrocks are unconformably cut and overlain by dacidic lava, tuff and pyroclastic rocks of the Oligo-Miocene aged Doyuran volcanics and the andesitic dykes, lavas and agglomerates of the Upper Miocene Hallaclar volcanics. The mineralizations are realgar, orpiment, galenite, sphalerite and pyrite in dacite cracks; in the cracks of the limestone, it consists of galenite, sphalerite, antimonite, pyrite, realgar and orpiment. Generally, ore minerals are composed of pyrite, marcasite, sphalerite, galena, chalcopyrite and arsenopyrite (Avin, 2011; Gul, 2014; Celik Balci et al., 2014; Bozan et al., 2017).

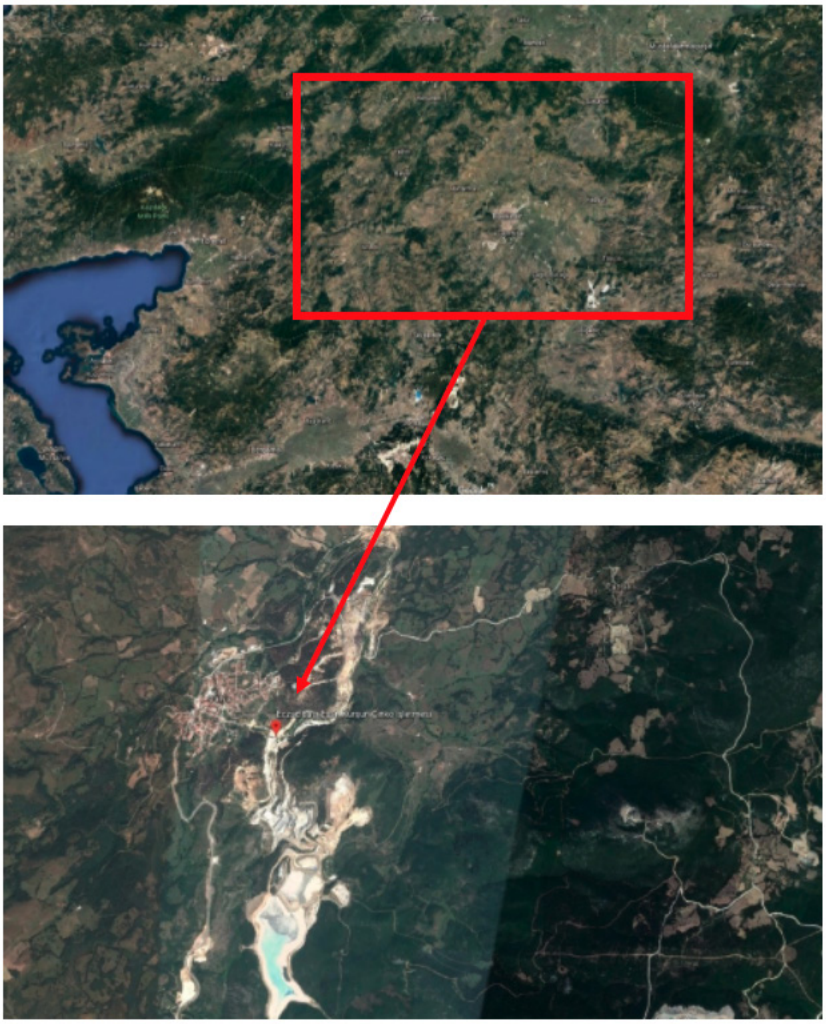

Figure 1. Balikesir Balya lead-zinc ore work area

2.2. Method

To determine the physical properties of the sample, firstly, moisture analysis was carried out without losing the original moisture content at 105oC with a UF450 model Memmert oven. Density analysis method with pycnometer was used to determine the density of the Pb-Zn sample. In all density experiments, 50 ml pycnometers and distilled water were used. The samples used in the density tests were reduced to -75 µm particle size with agate mortar and prepared for measurement. After reducing the size of the Pb-Zn sample using a jaw crusher, particle size analysis was performed by wet sieving method with using Retch brand sieves. After the sieving process, the samples obtained in different particle ranges were dried in the oven, and their weights were scaled to determine their particle size distribution. Moisture, density and particle size analyses were carried out according to ASTM standards.

Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) analyses were performed to obtain information about the elements contained in the copper ore. To be informed about the mineralogical properties of the samples, X-Ray Diffraction (XRD) analyses were performed with the Rigaku MiniFlex 600 brand XRD device. For getting information about the morphology of the samples, their photographs were taken with Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS) analyses were performed. ICP-OES, SEM and EDS analyses were carried out at the Mineral Analysis and Technology Department of the General Directorate of Mineral Research and Exploration. Within the scope of polish section studies, polish sections of the samples were prepared using Vommak brand natural stone and marble cutting device and Vommak brand polishing device. The polish sections obtained were analyzed and interpreted with the help of an Olympus BX51-P brand polarized light microscope.

The pH profile of the samples in pure water was obtained. Suspensions of 1% solids were prepared using -38 µm particle size material and ultrapure water. The suspensions prepared with 0.1 M HCl for the acidic medium and 0.1 M NaOH for the alkaline medium were mixed in a beaker with a magnetic stirrer at 500 rpm and the pH values of the suspensions were read at certain intervals during this process. pH-profile measurements of copper suspensions were performed using the HANNA HI2211 pH-meter.

Within the scope of particle shape factor studies, Scanning Electron Microscope (SEM) photographs of the samples in the particle size range of -45+38 µm, -75+63 µm and -150+106 µm were taken; and image processing was performed with ImageJ program.

3. Results

3.1. Physical properties of the sample

The high moisture content of the ore can cause problems in the crushing-sieving phase and prevent reaching the determined capacity. In addition, the material with high moisture content must be subjected to drying before benefication processes. For this reason, moisture analysis was carried out without losing the original moisture content, and it was defined that the Pb-Zn sample contained 0.069% moisture. From the results obtained, it was observed that the moisture content of the sample was not significant. The density analysis was carried out and the density of the raw Pb-Zn sample was found to be 4.89 g/cm^3. Particle size analysis was carried out to determine the particle size distribution of the sample.

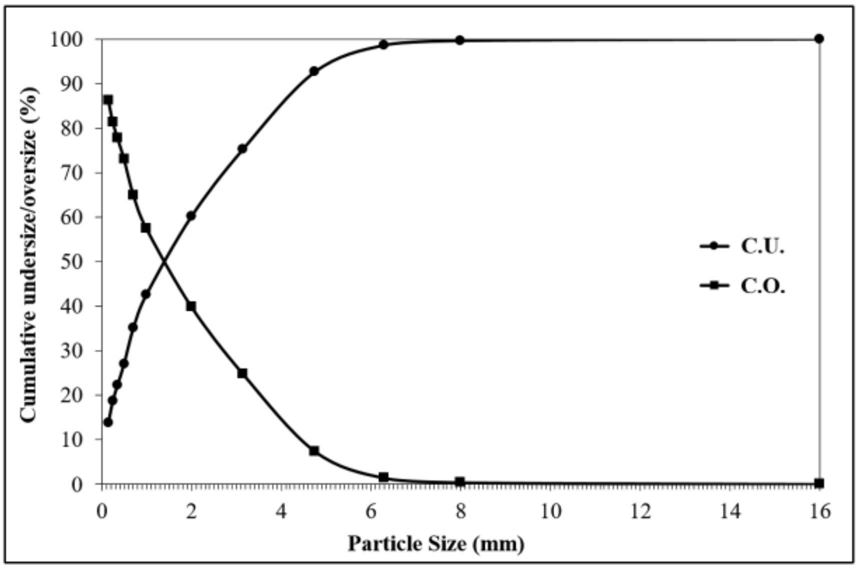

Figure 2. Oversize-undersize graphs of the sample

Table 1. The results of the particle size distribution of the sample

Sieve aperture (mm)	Content		Total	
	(g)	(%)	Oversize (%)	Undersize (%)
+8	6.08	0.382	0.382	100.000
-8+6.30	16.09	1.011	1.393	99.618
-6.30+4.75	95.91	6.026	7.419	98.607
-4.75+3.15	276.22	17.356	24.775	92.581
-3.15+2	240.58	15.116	39.891	75.225
-2+1	278.44	17.495	57.387	60.109
-1+0.710	118.82	7.466	64.852	42.614
-0.710+0.500	128.90	8.099	72.952	35.148
-0.500+0.355	76.29	4.794	77.745	27.049
-0.355+0.250	56.23	3.533	81.278	22.255
-0.250+0.150	78.05	4.904	86.182	18.722
-0.150+0.106	38.39	2.412	88.595	13.818
-0.106+0.075	31.73	1.994	90.588	11.406
-0.075+0.063	14.52	0.912	91.501	9.412
-0.063+0.045	23.74	1.492	92.992	8.500
-0.045+0.038	12.03	0.756	93.748	7.008
-0.038	99.50	6.252	100.000	6.252
Total	1591.52	100.000		

From the oversize-undersize graphs (Figure 2) drew up using the data in Table 1, the d_{50} and the d_{80} sizes of the sample were found as 1.4 mm and 3.55 mm, respectively.

3.2. Chemical properties of the sample

As a result of the XRF analysis (Table 2) and ICP-OES analysis (Table 3), it was determined that the sample contained 1,32% PbO, 2,20% ZnO, 1,4% Pb and 2,14% ppm Zn.

Table 2. XRF analysis results

Compound	Content (%)	Compound	Content (%)
CO_2	27.1	CaO	28.8
Na_2O	0.132	TiO_2	0.205
MgO	2.35	MnO	0.274
Al_2O_3	4.98	Fe_2O_3	6.33
SiO_2	18.1	CuO	0.104
SO_3	6.90	ZnO	2.20
K_2O	1.25	PbO	1.32

Table 3. ICP-OES analysis results

Compound	As	Cd	Co	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Zn
Content(ppm)	685	152	20	1121	>50000	2759	12	17	14108	173	<10	21356

3.3. Mineralogical properties of the sample

When the XRD results carried out to be informed about the mineralogical structure of the sample were examined (Figure 3), it was sighted that the sample contained quartz, dolomite, calcium carbide, sphalerite and calderite.

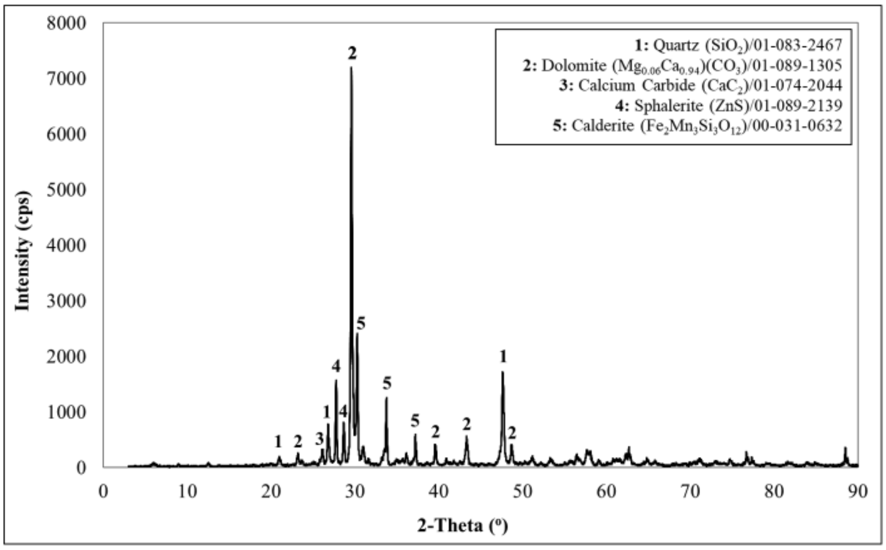

Figure 3. XRD diffraction figure of the sample

To define the elemental compositions of the sample and provide data on the chemical composition of the sample, scanning electron microscope (SEM) photographs were taken and EDS analyzes were carried out (Figure 4, Table 4).

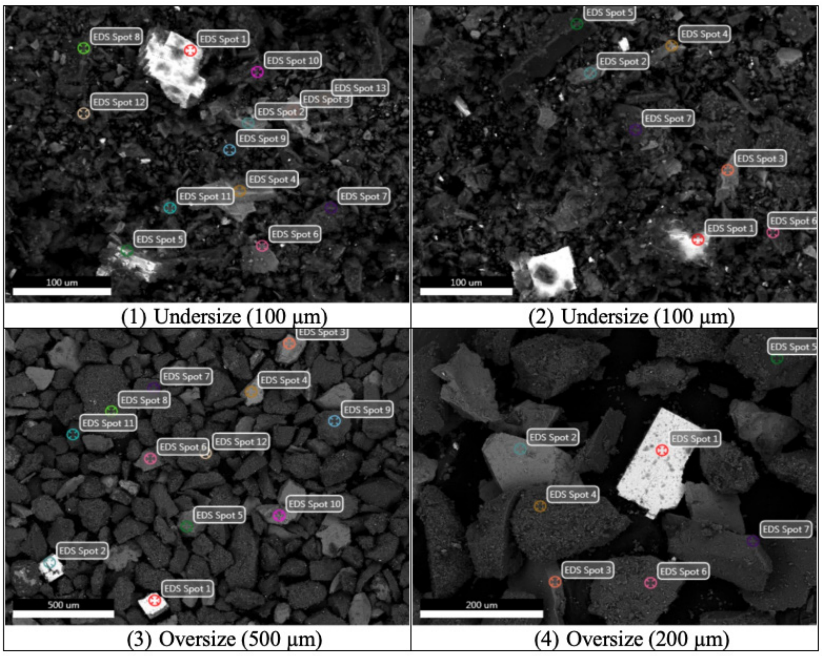

Figure 4. SEM photos of the sample subjected to EDS analysis

Table 4. EDS analysis results of the sample

		O		S		Ca		Pb		Zn	
		%W	**%A**	**%W**	**%A**	**%W**	**%A**	**%W**	**%A**	**%W**	**%A**
Undersize (100 µm)	**1**	13.10	50.43	12.17	23.37	1.59	2.45	71.29	21.19	0.00	0.00
	2	15.71	33.13	32.89	34.6	2.05	1.73	0.00	0.00	40.98	21.15
	3	18.16	38.65	28.45	30.21	2.37	2.02	0.00	0.00	43.70	22.76
	4	12.47	27.88	30.76	34.3	1.29	1.15	0.00	0.00	38.66	21.14
	5	21.75	59.38	10.37	14.12	4.66	5.08	56.23	11.85	0.00	0.00
	6	22.90	41.53	34.92	31.61	4.54	3.29	0.00	0.00	0.84	0.37
	7	45.21	63.4	0.61	0.42	19.45	10.89	0.00	0.00	0.00	0.00
	8	58.15	73.5	0.87	0.55	13.37	6.74	0.00	0.00	0.00	0.00
	9	52.75	66.36	0.00	0.00	0.52	0.26	0.00	0.00	0.00	0.00
	10	56.84	65.52	0.58	0.34	23.87	10.98	0.00	0.00	0.00	0.00
	11	49.92	68.28	0.63	0.43	17.68	9.65	1.76	0.19	0.00	0.00
	12	48.52	64.85	1.2	0.8	13.65	7.28	0.00	0.00	0.00	0.00
	13	45.79	65.15	0.49	0.35	21.08	11.97	0.00	0.00	0.00	0.00
	Avg.	**35.48**	**55.24**	**11.84**	**13.16**	**9.7**	**5.65**	**9.95**	**2.56**	**9.55**	**5.03**
Undersize	**1**	25.54	65.51	9.94	12.72	4.85	4.96	55.17	10.93	0.00	0.00
	2	9.36	20.56	43.41	47.57	1.08	0.94	0.00	0.00	0.00	0.00
	3	39.19	67.62	15.82	13.62	5.82	4.00	0.00	0.00	0.00	0.00
	4	12.52	28.70	31.29	35.80	1.35	1.24	0.00	0.00	46.24	25.95
	5	53.66	67.54	1.61	1.01	2.40	1.21	0.00	0.00	0.00	0.00
	6	55.48	64.30	2.56	1.48	21.94	10.15	0.00	0.00	0.27	0.08
	7	46.92	66.28	0.76	0.54	22.43	12.65	0.00	0.00	0.00	0.00
	Avg.	**34.67**	**54.36**	**15.06**	**16.11**	**8.55**	**5.02**	**7.88**	**1.56**	**6.64**	**3.72**
Oversize (500 µm)	**1**	10.46	45.62	10.33	22.47	1.48	2.58	75.68	25.48	0.00	0.00
	2	9.06	41.60	10.42	23.88	1.65	3.02	76.78	27.23	0.00	0.00
	3	3.99	11.04	31.62	43.61	0.29	0.32	0.00	0.00	58.17	39.35
	4	5.11	13.85	30.71	41.50	0.43	0.46	0.00	0.00	58.75	38.94
	5	12.74	27.27	38.90	41.52	1.08	0.92	0.00	0.00	0.00	0.00
	6	9.92	21.22	49.38	52.70	1.72	1.47	0.00	0.00	0.00	0.00
	7	48.78	62.08	0.61	0.39	36.26	18.42	0.00	0.00	0.00	0.00
	8	48.01	65.34	1.48	1.00	13.75	7.47	0.00	0.00	0.00	0.00
	9	40.17	58.23	0.88	0.64	24.22	14.01	0.00	0.00	0.00	0.00
	10	13.81	30.73	31.28	34.73	1.23	1.09	0.00	0.00	46.02	25.07
	11	51.70	65.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	44.42	60.09	0.00	0.00	16.06	8.67	0.00	0.00	0.00	0.00
	Avg.	**24.85**	**41.86**	**17.13**	**21.87**	**8.18**	**4.87**	**12.71**	**4.39**	**13.58**	**8.61**
Oversize (200 µm)	**1**	8.49	41.20	11.30	27.37	0.36	0.69	79.15	29.66	0.00	0.00
	2	4.89	13.05	33.75	44.91	0.59	0.63	0.00	0.00	56.28	36.73
	3	6.21	14.10	51.05	57.86	0.88	0.80	0.00	0.00	0.00	0.00
	4	54.51	65.32	0.00	0.00	32.78	15.68	0.00	0.00	0.00	0.00
	5	46.81	60.79	0.00	0.00	0.73	0.38	0.00	0.00	0.00	0.00
	6	32.64	52.26	0.00	0.00	29.02	18.55	0.00	0.00	0.00	0.00
	7	38.30	57.71	0.00	0.00	25.87	15.56	0.00	0.00	0.00	0.00
	Avg.	**27.41**	**43.49**	**13.73**	**18.59**	**12.89**	**7.47**	**11.31**	**4.24**	**8.04**	**5.25**

Avg.: Average, %W: weight, %A: atomic

When the results of the EDS analyzes were examined, an average of 9.95% Pb and 9.55% Zn contents for the 1st photo, 7.88% Pb and 6.64% Zn for the 2nd photo, 12.71% Pb and 13.58% Zn for the 3rd photo and 11.31% Pb and 8.04% Zn for the 4th photo were determined. It was sighted that the sulphur and calcium ratio of the sample was high. In addition to the elements given in the table, the presence of Al, Fe, Mg, Si, Cu, Cd, Mn, Ni, Sr, K, Na, C and Ti was also found in the sample.

When the polish section photographs of the Pb-Zn sample (Figure 5) were investigated, galena, sphalerite and a very small amount of pyrite were observed in the Pb-Zn sample. Chalcopyrite inclusions in sphalerites form interim paragenesis and are anhedral. Galenas are considered as fissured, anhedral and isotropic. There are no pressure twinnings, it has not been exposed to much pressure. Sphalerites are less abundant than galena. Chalcopyrite is inclusionous. As a gangue mineral anisotropic limestone is observed in the form to represent the barren rock. Pyrites are shiny, anhedral, light colored and spongy. The domination of the gangue minerals is in question. In the form of small pseudomorphs, iron sulphides are seen as inclusions in the gangue. Secondary iron oxide staining exists at the point of cracks and fractures. Galena is non-abundant.

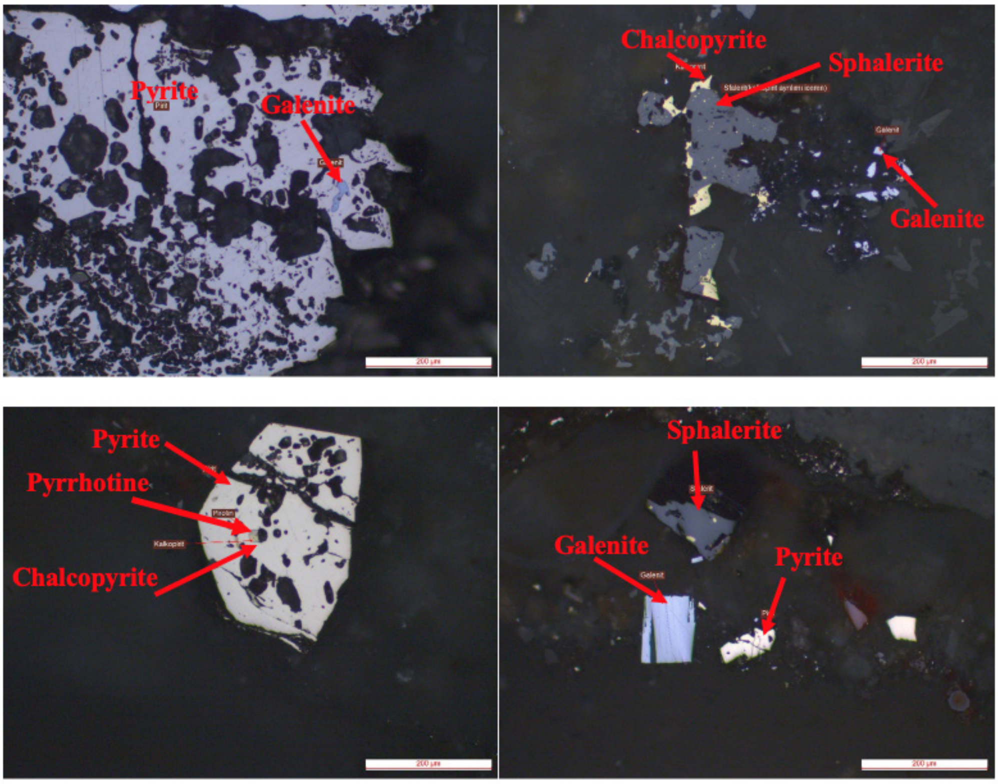

Figure 5. Polish section photos of the sample

3.4. pH profile of the sample

The pH profile of the samples in pure water was obtained. Accordingly, the time-dependent pH changes of the samples were investigated (Figure 6).

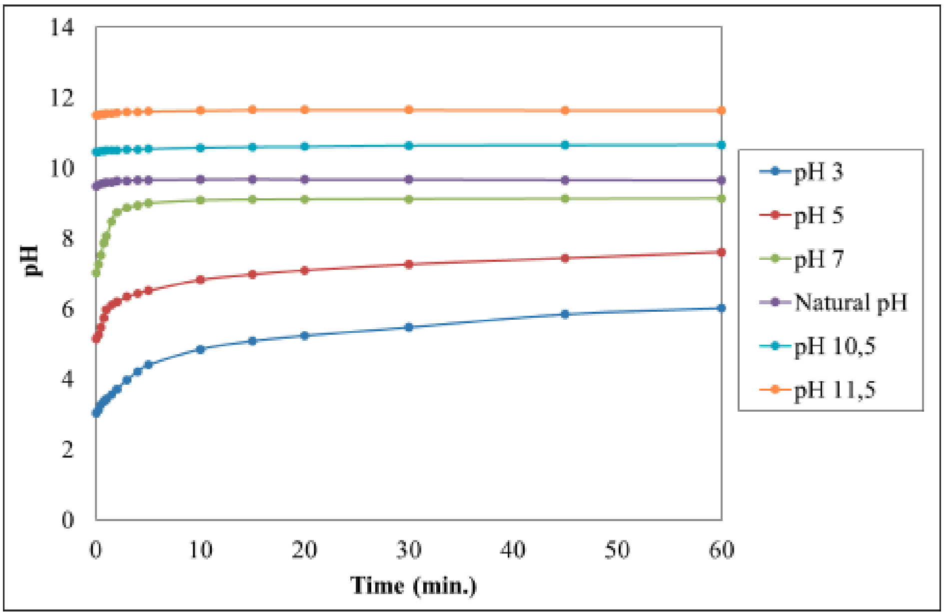

Figure 6. pH profile of the sample

Experiments to determine the pH profile of the sample were carried out at the sample's own natural pH of 9.49 and pH 3, 5, 7, 10.5 and 11.5. When the pH profile obtained was examined, it was sighted that the pH value of the sample started to reach a buffer pH value in the basic region after a certain period of time in pH 3, pH 5 and pH 7 experiments. There was no significant time-dependent change at the alkaline pH values of 10.5 and 11.5. The reason for this can be explained by the alkaline property of the sample due to its high carbonate content and the limited amount of cations that dissolve from the sample and pass into the solution.

3.5. Determination of the sample's particle shape factor

When the behavior of the particle is examined in all processes such as the determination of processes in ore benefication, the selection of the tools to be used in the processes, the evaluation of their performance; in order for the system to operate at the required efficiency at the whole work such as transporting, stocking, dewatering and/or filtration of the concentrate and residue before and after the benefication, the particle shape emerges as an important parameter. Characterization of particle shape is quite significant in both academic and industrial environments. In the mineral industry, flotation, jigging, sieving, classification, shaking table, heavy fluid separation, cyclone and many other methods are sensitive to particle shape.

Particle shape, which is generally defined with qualitative terms such as round, angular and flat, is an important parameter to determine the behavior of the particle in the selection and success of processes in ore preparation and beneficiation. Therefore, it is necessary to quantitatively measure and describe the particle shape. To date, many techniques have been developed in the field of describing particle shape characterization. However, there is still no universally accepted method that measures shape properties alone. Nevertheless, there are methods that measure particle shape parameters and the results can be used scientifically. Image analysis technique is one of these methods and is widely used.

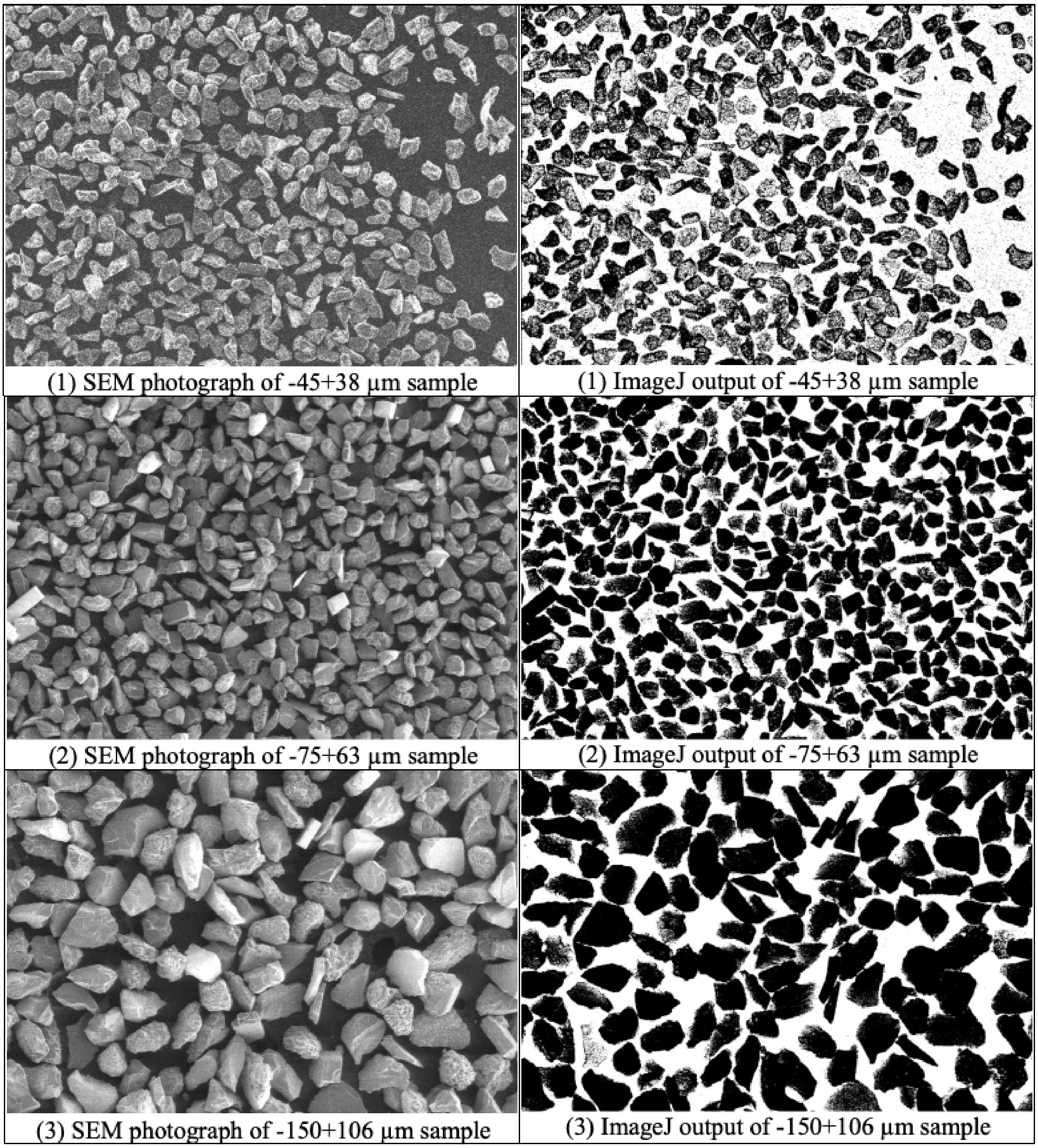

Figure 7. SEM photos and ImageJ outputs of Pb-Zn (-45+38 µm, -75+63 µm and -150+106 µm) samples

In this study, Scanning Electron Microscope (SEM) photographs of the samples in the particle size range of -45+38 µm, -75+63 µm and -150+106 µm were taken within the scope of particle shape factor studies; and image processing was performed with ImageJ program (Figure 7). Average circularity, roundness and solidity values were respectively found to be 0.180, 0.574 and 0.596 for the sample with -45+38 µm particle size; 0.252, 0.563 and 0.720 for the sample with -75+63 µm particle size; 0.264, 0.582 and 0.749 for the sample with 150+106 µm particle size (Table 5).

Figure 7. SEM photos and ImageJ outputs of Pb-Zn (-45+38 µm, -75+63 µm and -150+106 µm) samples

	Circularity				Roundness				Solidity			
	Avg.	SD	Min	Max	Avg.	SD	Min	Max	Avg.	SD	Min	Max
(1)	0.180	0.148	0.006	0.611	0.574	0.168	0.109	0.985	0.596	0.140	0.325	1.000
(2)	0.252	0.172	0.010	0.713	0.563	0.186	0.150	0.962	0.720	0.142	0.345	0.932
(3)	0.264	0.168	0.015	0.571	0.582	0.189	0.289	0.918	0.749	0.182	0.250	0.942

4. Discussions and Conclusion

In this study, detailed characterization studies were carried out with the Balikesir Balya region lead-zinc ore; the circularity, roundness and solidity values of the ore were determined by image analysis method. According to the results obtained from the experiments carried out to determine the physical properties of the sample, the moisture content of the sample was 0.069%, the density was 4.89 gr/cm^3, d_{50} and d_{80} sizes were respectively found to be 1,4 mm and 3,55 mm. As a result of the XRF and ICP-OES analyses carried out to determine its chemical properties, it was determined that the sample respectively contained 1,32 PbO%, 2,20% ZnO, 1,41% Pb and 2,14% Zn. When XRF and ICP-OES analysis results were compared, it was seen that the results were compatible. As a result of the XRD analysis performed to determine the mineral composition of the sample, it was sighted that the sample contained quartz, dolomite, calcium carbide, sphalerite and calderite. When the results of the EDS analyses were examined, an average of 9.95% Pb and 9.55% Zn contents for the 1st photo, 7.88% Pb and 6.64% Zn for the 2nd photo, 12.71% Pb and 13.58% Zn for the 3rd photo and 11.31% Pb and 8,04% Zn for the 4th photo was determined. As the result of the polish section studies, it has been observed that lead is in the form of galena mineral which has considered as fissured, anhedral and isotropic, and zinc is in the form of sphalerite. When the XRD, EDS and polish section studies were examined, it was seen that the mineralogical findings obtained from these three analyzes were consistent. When the pH profile of the sample was examined, it was observed that the pH value of the sample started to reach a buffer pH value in the basic region after a certain period of time in pH 3, pH 5 and pH 7 experiments. Within the scope of particle shape factor studies, circularity, roundness and solidity values of Pb-Zn samples in the particle size range of -45+38 µm, -75+63 µm and -150+106 µm were determined. It was observed that average circularity, roundness and solidity values tended to increase as the partical size increased.

The physical, chemical and mineralogical properties of Balikesir Balya lead-zinc ore, the presence of lead and zinc in the ore and the determination of their relationship with other minerals in the ore are of great importance in choosing the appropriate benefication method. With the correct characterization of the ore and then the selection of an appropriate process, high amounts of metal concentrate will be produced. Because the sample is a sulphide, complex and low grade ore, flotation is a suitable method for benefication. Since the flotation method is used for the benefication of fine-sized liberated ores, the particle size distribution analysis of the sample was examined and it was observed that the mineral can be liberated in fine sizes. In addition, various studies have been conducted to investigate methods that can be alternative to flotation in lead-zinc benefication (Aytekin, 1979; Tkacova et al., 1993; Rehman et al., 2009; Ozboz et al., 2017; Abraitis et al., 2018). The characterization tests and particle shape factor studies performed in this study showed that more scientific research can be done on the recovery of lead and zinc contents with known ore processing methods on Balikesir Balya lead-zinc ore samples, and new methods can be tried.

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