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Scanning Electron Microscopy (SEM) Character of Metamorphic-hosted Bauxite Mineralization in Eastern Taurus Orogenic Belt

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Abstract – One of the main tectonic belts in Türkiye is the Taurus Orogenic Belt, where significant bauxite mineralizations are observed. The bauxite deposits in Doğanşehir (Malatya, Türkiye) occur as massive bodies and lenses within the carbonate rocks of the Permian-Triassic Malatya Metamorphics in the Eastern Taurus Orogenic Belt. The region's geological foundation comprises lithologies belonging to the Malatya Metamorphics. This unit consists primarily of schists, calc-schists, and marble, which are overlain by the Late Cretaceous-Eocene Berit Metaophiolite, Eocene Maden Complex, Early-Middle Eocene Doğanşehir Granitoid, and Plio-Quaternary cover sedimentary units. Oolitic and pisolitic bauxite mineralizations are present within the Permian-Triassic carbonate rocks (Malatya Metamorphics). These mineralizations occur in carbonate rocks that contain fossils and are observed in the form of lenses. The bauxite lenses are overlain by relatively thin, middle-layered Permian-Triassic carbonate rocks (Malatya Metamorphics). With the advancement of technology, Scanning Electron Microscopy (SEM) has been used for the analysis of bauxite ores to determine the presence of elements within their crystal lattice structure. The point analysis and mapping method were employed to identify the elements that could be present within the crystal lattice structure of the bauxite ores. The SEM analysis of the samples using the mapping method revealed the distribution of Fe, Ti, Si, Al, and O elements before and after activation. The images indicate that bauxite exhibits a broad grain distribution, both below and above 50 µm. The elemental spectrum diagram shows the presence of O, Al, and Si in the sample. Additionally, Fe, Ti, C, K, and Mg were also detected. Using SEM analysis of the same samples and the mapping method, the distribution of Fe, Ti, Si, Al, and O elements in the structure was examined before and after activation. As seen from the images, the elements Al, O, and Si exhibit high density in certain areas before activation show a more homogeneous distribution and similar structures after activation. Fe, Mg, and K display a similar distribution pattern, while Ti and C exhibit different characteristics.

Keywords – Taurus Orogenic Belt, Bauxite, Malatya Metamorphics, SEM, Doğanşehir (Malatya-Türkiye)

I. INTRODUCTION

Bauxite, a sedimentary rock that serves as the primary source of aluminum ore, has captivated the scientific community for decades. Comprehending the complex mineralogical and chemical composition of bauxite is essential for improving its extraction, refining, and eventual applications. Classic characterization techniques have given valuable insights, but with advanced imaging technologies, scientists have gained access to an exceptional level of detail. Among these innovative tools, Scanning Electron Microscopy (SEM) has emerged as a powerful method [1] for mapping the microcosm of bauxite.

The advantages of Scanning Electron Microscopy in bauxite analysis are abundant, especially due to its ability to provide high-resolution, three-dimensional imaging. The surface topographies of the material can be revealed and detailed information about the elemental composition can be obtained by using SEM to bombard a sample with a focused electron beam and capturing the signals. By using these capabilities, researchers can examine the microstructural differences in bauxite deposits, detect mineral phases, and analyze the spatial arrangement of essential elements [2-4].

The Tauride Belt, in structural terms, is characterized by the prevalence of autochthonous and nappe structures. Within this belt, Türkiye boasts a wealth of bauxite deposits, exhibiting diverse ages and formation types. Among these deposits, the karst type stands out as the most significant.

The Tauride Belt, which can be further divided into the Western, Central, and Eastern Taurus Mountains, comprises geological units where tectonic slices are juxtaposed [5]. The research area is situated within the Eastern Tauride Belt, known for its tectonic activity, and it is characterized by the presence of bauxite deposits within carbonate rocks. The initial investigations of the bauxite occurrences in Doğanşehir were conducted by the General Directorate of Mineral Research and Exploration [6]. In this paper, we explore the scope and significance of using SEM to delve into the intricate structures and elemental constituents present in Doğanşehir bauxite.

II. Materials and Method

Scanning Electron Microscopy (SEM) analysis was carried out at Munzur University SEM/XRD Advanced Analysis Laboratory on Rigaku X-Ray Diffraction device. This device is an Advanced Analysis and Characterization device that allows detailed examination of the image of micron and nano-sized objects or particles (50-60 microns) by magnifying them (max 1.000.000 times) with the help of several types of lenses. In this study, the point and mapping method was used to determine the elements that may be present in the crystal lattice structure of the bauxite sample.

A. *General Geology and Mineralization*

The bauxite mineralization in Doğanşehir, located in Malatya, is situated within the tectonically active Eastern Tauride Belt. The basement of this region is formed by the Permo-Triassic Malatya Metamorphics. Overlying this unit, there are several geological formations, including the Late Cretaceous-Eocene Berit Metaophiolite, Eocene Maden Complex, Early-Middle Eocene Doğanşehir Granitoid, and Plio-Quaternary cover sedimentary units [7]. Ertürk et al. [8] interpreted the isotope and geochemical data of young volcanic rocks and pointed out that felsic rocks were formed during the post-collisional tectonic environment in the upper crust.

Within the Permo-Triassic carbonate rocks, there are oolitic and pisolitic bauxite mineralizations. These mineralizations occur in carbonate rocks that contain fossils and are observed in the form of lenses. The bauxite lenses are overlain by relatively thin, middle-layered Permo-Triassic carbonate rocks.

B. *SEM Analysis*

SEM of bauxite samples taken from the field images are given in Figure 1 respectively. The image shows that bauxite has a wide grain distribution, both below and above 50 µm.

The elemental spectrum diagram and table of this image are given in Figure 2. The results of the analysis show that the sample contains O, Al, and Si respectively. In addition to these elements Fe, Ti, C, K, and Mg were also detected (Figure 2).

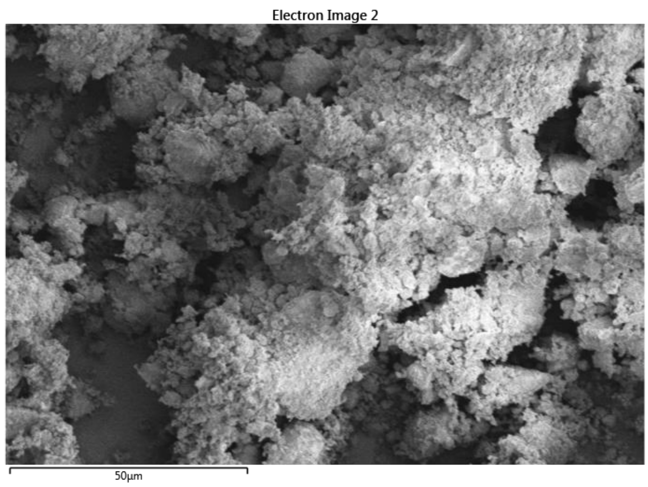
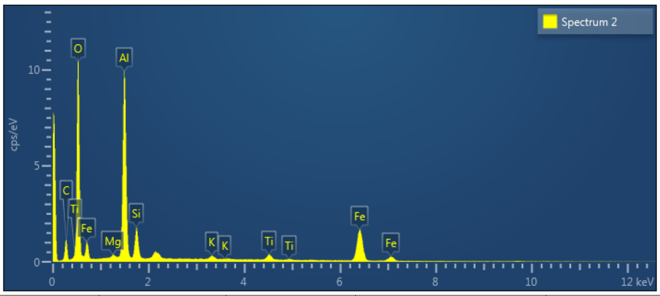


Fig. 1 SEM image of bauxite



Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	45.27	0.30	54.34
Al	K series	14.58	0.12	10.37
Si	K series	2.51	0.05	1.71
Fe	K series	19.43	0.21	6.68
Ti	K series	1.30	0.06	0.52
C	K series	16.25	0.42	25.99
K	K series	0.46	0.04	0.23
Mg	K series	0.21	0.03	0.16
Total		100.00		100.00

Fig. 2 Spectrum diagram and table.

With the help of SEM analysis of the same samples, the distribution of Fe, Ti, Si, Al, and O elements in the structure before and after activation was also examined by using the mapping method (Figure 3). As can be seen from the figures, Al, O, and Si elements, which are concentrated in certain regions before activation, show a more homogeneous distribution after activation and present similar structures. Fe, Mg, and K show a similar distribution while Ti and C show different characteristics.

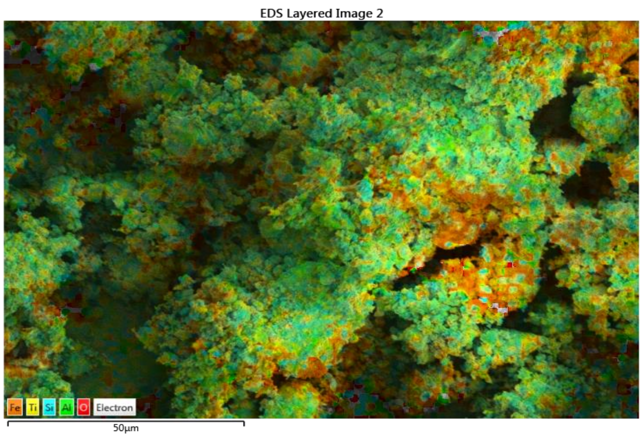


Fig. 3 SEM image of bauxite using the mapping method.

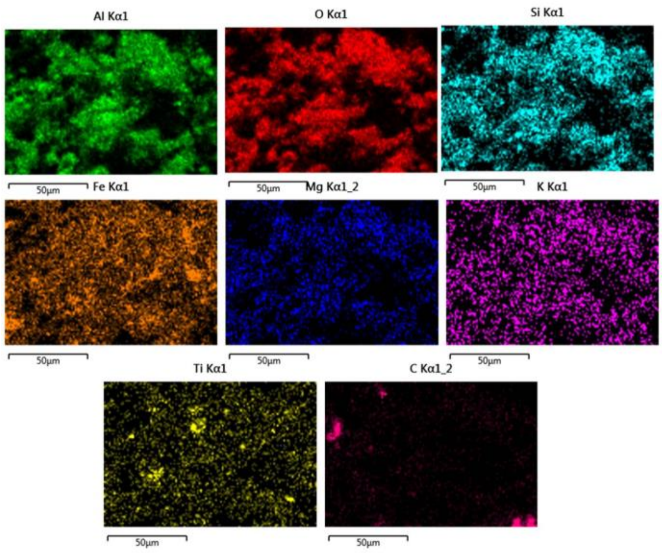


Fig. 4 Representative SEM image of bauxite's elemental compositions using the mapping method.

III. Results

In this article, we explore the scope and significance of using SEM to delve into the intricate structures and elemental constituents present in Doğanşehir bauxite. We will discuss the principles underlying SEM, highlight its advantages over other microscopy techniques, and examine the various applications that have propelled bauxite research to new frontiers.

Furthermore, SEM-based elemental mapping techniques provide a deeper understanding of the geochemical processes involved in bauxite formation. By correlating the spatial distribution of elements with mineral assemblages, researchers can decipher the complex interplay of geological, geochemical, and hydrological factors that shape bauxite deposits. This knowledge contributes to refining geological models, enhancing exploration strategies, and even potentially identifying new deposits.

IV. Discussion

The insights gained from SEM analysis have numerous implications for the bauxite industry. Detailed knowledge of the bauxite microstructure can facilitate better ore characterization, aiding in the selection of appropriate mining and processing methods. Moreover, SEM allows for the identification of deleterious minerals or impurities that may impact the quality and efficiency of alumina production. Such information can guide the development of strategies to mitigate these challenges, leading to improved refining processes and increased aluminum yields.

V. CONCLUSION

In conclusion, Scanning Electron Microscopy has revolutionized the investigation of bauxite, unlocking a new level of understanding about its microstructure, mineralogical composition, and elemental distribution. The ability to visualize and analyze bauxite samples at high resolution has far-reaching implications, impacting the entire life cycle of bauxite, from mining and processing to refining and applications. As research in this field progresses, SEM continues to shape our understanding of bauxite, providing critical insights that drive innovation and sustainability in the aluminum industry.

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