**PERLİT OCAKLARINDAKİ OKSİT VE TOPRAK ALKALİ METAL DAĞILIMLARININ BELİRLENMESİ**

**Savaş TÜRKDOĞAN**

Kastamonu University, Institute of Science, Department of Physics, 37150 Kuzeykent, Kastamonu

**ORCID:**

**Aybaba HANÇERLİOĞULLARI**

Kastamonu University, Faculty of Science, Department of Physics, 37150 Kuzeykent, Kastamonu

**ORCID:** 0000-0000-1700-8480

**Aslı KURNAZ**

Kastamonu University, Faculty of Science, Department of Physics, 37150 Kuzeykent, Kastamonu

**ORCID:** 0000-0002-7910-3461

**Şeref TURHAN**

Kastamonu University, Faculty of Science, Department of Physics, 37150 Kuzeykent, Kastamonu

**ORCID:** 0000-0001-5303-3680

**ÖZET**

Perlit volkanik kökenli bir kayaçtır. Soğuyan lavların hidrasyonuyla doğal olarak oluştuğu için volkanik cam olarak da isimlendirilir. Perlit minerali nispeten büyük miktarlarda kimyasal olarak bağlı su içerir ve bu özelliği genişlemesine neden olur. Perlitler mineralleri, tavan döşemelerinde, boru izolasyonunda, alçı duvar kaplamasında, kriyojenik izolasyonda, dolgu maddelerinde, filtreleme malzemelerinde, hafif çimento için agregatların hazırlanmasında, ağır metallerin uzaklaştırılmasında ve partiküllerin atmosferden adsorbsiyonunda, ısı yalıtkanlarında, yağın emilmesinde, çatı panellerinde, köpüklerde, yangın geciktiricilerde, tuğla ürünlerinde, bahçecilikte, cam kap üretiminde, mikroorganizma taşıyıcılarında, çimento harcının mekanik ve termal özelliklerini iyileştirilmesinde kullanılan çok yönlü malzemelerdir. Bu minerallerin, hangi sektörde nasıl kullanılacağı kimyasal içeriğine bağlıdır. Bu yüzden Türkiye'deki perlit ocaklarının majör ve minör oksit dağılımlarının belirlenmesi önem arz etmektedir. Bu çalışmada ilk kez Türkiye'nin farklı şehirlerinde bulunan 12 perlit ocağından toplanan 126 perlit örneği ilk defa ayrıntılı olarak analize tabi tutuldu. Perlit örneklerindeki majör-minör oksitlerin ve toprak alkali metallerin (Mg, Ca, Ba ve Sr) seviyeleri,bir enerji dağılımlı X-ışını floresans spektrometresi kullanılarak belirlendi. İncelenen sepiyolit örneklerinde analiz edilen majör ve minör oksitler ortalama derişimlerine (mg/kg cinsinden) göre SiO2 (75.18) > Al2O3 (15.65) > Na2O (5.94) > K2O (3.49) > Fe2O3 (0.94) > CaO (0.71) > MgO (0.56) > TiO2 (0.09) > MnO (0.02) olarak sıralandı. Perlit örneklerinde analiz edilen Ca, Mg, Ba ve Sr’nin ortalama derişimleri, sırasıyla 5099 mg/kg, 3333 mg/kg, 569 mg/kg ve 50 mg/kg olarak bulundu.

**Anahtar Kelimeler:** Perlit, majör ve minör oksitler, toprak alkali metal, EDXRF

**DETERMINATION OF OXIDE AND ALKALINE EARTH METAL DISTRIBUTIONS IN PERLITE MINERALS**

**ABSTRACT**

Visualization is a fundamental component of statistical analysis and prediction, enabling clear data description and informed model selection. While various methods exist for visualizing event data, there is a notable gap in representing events on a clock face. In this paper, we introduce clockplot, a method to plot timestamped events on a 24-hour circular clock face. This approach offers a powerful way to perceive the precise timing of events and facilitates intuitive comparisons with other events. The clockplots are particularly useful for analyzing daily patterns, event clustering, and temporal gaps. For event times, it is significantly more revealing than conventional visualizations like bar or pie charts. This technique enables effective event planning and pattern analysis across multiple periods, providing a new and insightful tool for temporal data analysis.

**Keywords:** Visualization, Timestamp, Pattern

**1. INTRODUCTION**

The origins of modern statistical graphics are most notably traced to the late 18th century, when William Playfair introduced the line chart, bar chart, and pie chart as innovative visual forms for representing economic data in his seminal works The Commercial and Political Atlas (Playfair, 1786) and The Statistical Breviary (Playfair, 1801). These developments marked a foundational shift from numerical tables to visually intuitive representations of quantitative information. Earlier antecedents, including Priestley’s timelines (Priestley, 1765) and even medieval kinematic diagrams, provided important conceptual and practical precursors to these advances.

Throughout the 19th century, graphical methods expanded into new domains, including thematic cartography—exemplified by Dupin’s choropleth maps—and polar-area diagrams, such as those developed by Florence Nightingale for communicating causes of mortality in military hospitals (Friendly, 2008). By the fin de siècle, Karl Pearson had formalized the histogram as a rigorous tool for representing continuous distributions, thereby cementing its role in statistical practice (Pearson, 1895).

In the mid-to-late 20th century, John Tukey’s development of the box-and-whisker plot—popularized in his 1977 work Exploratory Data Analysis—provided a compact, non-parametric summary of distributions using quartiles and outliers (Tukey, 1977). More broadly, his framework for Exploratory Data Analysis (EDA) elevated the role of visualization as essential for uncovering latent structures beyond the scope of confirmatory methods.

Each of these graphical forms has since undergone substantial refinement through both technological and methodological innovations—including notched boxplots, density plots, donut charts, and interactive geographic overlays—continuing to enhance the clarity, utility, and interpretive depth of statistical communication (Wickham & Grolemund, 2017; Unwin, 2020).

**2. MATERIAL AND METHODS**

**2.1. Collection and preparation**

A total of 126 perlite samples were obtained from 12 perlite quarries (PERQs) located in Erzurum, İzmir, Ankara, and Nevşehir provinces of Turkey (Table 3). The perlite samples were carried to the laboratory of sample preparation and dried in a temperature–controlled furnace at 110 C for 15 h to remove moisture. Then, the samples were crushed and pulverized to get the calibrated powder geometry. A few grams of each perlite sample were taken for analysis.

**Table 3.** Information on perlite quarries

|  |  |  |
| --- | --- | --- |
| Quarry code | Number of sample | Location |
| PERQ1 | 10 | Erzurum (Pasinler) |
| PERQ2 | 10 | Erzincan (Mollaköy) |
| PERQ3 | 10 | İzmir (Mezarkaya) |
| PERQ4 | 10 | Ankara (Çubuk) |
| PERQ5 | 7 | Nevşehir (karapınar) |
| PERQ6 | 10 | Nevşehir (Acıgöl) |
| PERQ7 | 10 | Nevşehir (Göllü Dağı) |
| PERQ8 | 8 | İzmir (Bergama, Koyuneli) |
| PERQ9 | 15 | İzmir (Bergama, Pınar köyü) |
| PERQ10 | 10 | Nevşehir (Nenezi Dağı) |
| PERQ11 | 10 | İzmir (Bergama, Örlemiş) |
| PERQ12 | 16 | İzmir (Bergama) |

**2.2. Analysis technique**

Elemental analysis of perlite samples was performed by an EDXRF spectrometer (Spectro Xepos, Ametek) with a thick binary Pd/Co alloy anode X-ray tube (50 kV, 60 W), in the Central Research Laboratory of Kastamonu University. The EDXRF spectrometer was equipped with a thick binary Pd/Co end-window tube (50 W, 60 kV) and a Peltier-cooled Si drift detector. The EDXRF spectrometer uses the “standardless” calibration based on the Fundamental Parameters method. (Turhan et al. 2020; Turhan et al. 2022; Altıkulaç et al. 2022). NIST SRM 2709 reference material was utilized for quality assurance of the EDXRF spectrometer (Turhan et al. 2020). Perlite samples were placed in the automatic sampler and counted once for two hours, and the analysis processes were completed.

**3. RESULTS AND DISCUSSION**

**3.1. Major and minor oxides of perlite samples**

Some descriptive statistical data such as average, standard error (SE), standard deviation (SD), median, etc. on the concentrations of oxides analyzed in all perlite samples are presented in Table 4. A comparison of average concentrations of major and minor oxides analyzed in Turkish perlites with Earth’s continental crust is shown in Fig. 1. The average and range (min-max) values of oxides analyzed in perlite quarries are given in Table 5.

## Table 4. Some descriptive statistical data on the concentrations of oxides

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Concentration of oxides in perlite samples | | | | | | | | | |
| Na2O | MgO | Al2O3 | SiO2 | P2O5 | K2O | CaO | TiO2 | MnO | Fe2O3 |
| Average | 5.941 | 0.557 | 15.653 | 75.184 | 0.024 | 3.487 | 0.710 | 0.087 | 0.049 | 0.937 |
| SE | 0.139 | 0.034 | 0.077 | 0.151 | 0.001 | 0.049 | 0.023 | 0.003 | 0.001 | 0.020 |
| Median | 6.596 | 0.415 | 15.635 | 75.290 | 0.025 | 3.622 | 0.693 | 0.086 | 0.049 | 0.894 |
| SD | 1.563 | 0.386 | 0.861 | 1.696 | 0.006 | 0.550 | 0.258 | 0.034 | 0.009 | 0.221 |
| Kurtosis | -1.582 | -1.148 | 4.058 | 18.690 | -0.828 | 0.586 | -0.708 | -0.745 | -1.132 | -1.094 |
| Skewness | -0.094 | 0.588 | -1.000 | -2.389 | -0.408 | -0.958 | 0.157 | -0.299 | 0.117 | 0.231 |
| Min | 3.300 | 0.052 | 11.320 | 63.280 | 0.011 | 2.022 | 0.245 | 0.020 | 0.033 | 0.560 |
| Max | 8.505 | 1.334 | 17.260 | 79.090 | 0.037 | 4.268 | 1.203 | 0.139 | 0.066 | 1.349 |

According to their average, the oxides analyzed in perlite samples are listed as SiO2 > Al2O3 > Na2O > K2O > Fe2O3 > CaO > MgO > TiO2 > MnO.

The SiO2 concentrations in Turkish perlites varied from 63.28 (perlite sample from PERQ4) to 79.09% (perlite sample from PERQ8) with a mean of 75.18%. As shown in Fig. 1, the average SiO2 concentration is 1.4 times higher than the average value of Earth's continental crust of 54.55% (Yaroshevsky 2006). From Table 5, the highest SiO2 concentration was analyzed in the PERQ3. The average SiO2 concentrations in perlite quarries are summarized in descending order as follows: PERQ3 > PERQ8 > PERQ5 > PERQ1 > PERQ7 > PERQ9 > PERQ4 > PERQ12 > PERQ2 > PERQ6 > PERQ10 > PERQ11.

The Al2O3 concentrations in Turkish perlites varied from 11.32 (perlite sample from PERQ4) to 17.26% (perlite sample from PERQ12) with a mean of 15.65%. The average Al2O3 concentration is very close to the average value of Earth's continental crust of 15.87% (Yaroshevsky 2006). However, the average Al2O3 concentrations analyzed in perlite samples from PERQ12, PERQ9, and PERQ1 are above the average value of Earth's continental crust. The highest Al2O3 concentration was analyzed in the PERQ12. The average Al2O3 concentrations in perlite quarries are summarized in descending order as follows: PERQ12 > PERQ9 > PERQ1 > PERQ10 > PERQ11 > PERQ6 > PERQ2 > PERQ7 > PERQ4 > PERQ3 > PERQ8 > PERQ5.

|  |
| --- |
| a) |
| b) |

**Fig. 1.** Comparison of major (a) and minor (b) oxides averages with the Earth's crust average

## Table 5. Concentrations of major and minor oxides in perlite quarries

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample code |  | Concentration of oxides (%) | | | | | | | | | |
| Na2O | MgO | Al2O3 | SiO2 | P2O5 | K2O | CaO | TiO2 | MnO | Fe2O3 |
| PERQ1 | Average | 4.74 | 0.42 | 16.18 | 76.09 | 0.02 | 4.01 | 0.36 | 0.08 | 0.04 | 0.95 |
|  | Min | 4.50 | 0.41 | 15.92 | 75.97 | 0.02 | 3.62 | 0.29 | 0.07 | 0.03 | 0.82 |
|  | Max | 5.07 | 0.44 | 16.60 | 76.26 | 0.03 | 4.27 | 0.41 | 0.09 | 0.04 | 1.02 |
| PERQ2 | Average | 7.70 | 0.15 | 15.29 | 74.48 | 0.01 | 3.49 | 0.68 | 0.02 | 0.05 | 1.01 |
|  | Min | 7.41 | 0.14 | 15.12 | 74.09 | 0.01 | 3.10 | 0.58 | 0.02 | 0.04 | 0.88 |
|  | Max | 8.30 | 0.18 | 15.71 | 74.70 | 0.01 | 3.65 | 0.73 | 0.03 | 0.05 | 1.12 |
| PERQ3 | Average | 4.25 | 0.41 | 14.96 | 77.15 | 0.03 | 4.04 | 0.77 | 0.08 | 0.04 | 1.14 |
|  | Min | 3.97 | 0.33 | 14.73 | 76.96 | 0.02 | 3.59 | 0.52 | 0.07 | 0.03 | 0.97 |
|  | Max | 4.76 | 0.46 | 15.41 | 77.28 | 0.04 | 4.25 | 0.90 | 0.09 | 0.04 | 1.22 |
| PERQ4 | Average | 5.66 | 0.99 | 15.19 | 75.10 | 0.02 | 2.37 | 0.66 | 0.07 | 0.05 | 0.78 |
|  | Min | 3.30 | 0.63 | 11.32 | 63.28 | 0.02 | 2.02 | 0.53 | 0.06 | 0.04 | 0.62 |
|  | Max | 7.54 | 1.21 | 16.14 | 78.99 | 0.02 | 2.81 | 0.78 | 0.09 | 0.06 | 0.93 |
| PERQ5 | Average | 7.84 | 0.08 | 14.55 | 76.13 | 0.01 | 3.09 | 0.28 | 0.03 | 0.06 | 0.79 |
|  | Min | 7.38 | 0.05 | 14.11 | 75.91 | 0.01 | 2.78 | 0.25 | 0.03 | 0.05 | 0.68 |
|  | Max | 8.26 | 0.11 | 14.83 | 76.47 | 0.01 | 3.45 | 0.32 | 0.04 | 0.07 | 0.90 |
| PERQ6 | Average | 7.66 | 0.17 | 15.29 | 73.90 | 0.03 | 3.42 | 0.94 | 0.08 | 0.05 | 1.26 |
|  | Min | 7.35 | 0.16 | 15.08 | 73.62 | 0.02 | 3.02 | 0.79 | 0.07 | 0.05 | 1.06 |
|  | Max | 8.26 | 0.18 | 15.79 | 74.09 | 0.03 | 3.58 | 0.99 | 0.09 | 0.06 | 1.35 |
| PERQ7 | Average | 6.78 | 0.21 | 15.24 | 75.82 | 0.02 | 3.48 | 0.39 | 0.06 | 0.06 | 0.80 |
|  | Min | 6.39 | 0.19 | 14.98 | 75.48 | 0.02 | 3.10 | 0.34 | 0.05 | 0.05 | 0.68 |
|  | Max | 7.29 | 0.24 | 15.65 | 76.03 | 0.02 | 3.75 | 0.44 | 0.07 | 0.06 | 0.90 |
| PERQ8 | Average | 6.53 | 0.54 | 14.60 | 76.58 | 0.02 | 2.55 | 0.69 | 0.08 | 0.05 | 0.80 |
|  | Min | 4.11 | 0.45 | 13.41 | 75.19 | 0.01 | 2.02 | 0.53 | 0.06 | 0.04 | 0.59 |
|  | Max | 8.51 | 0.59 | 15.35 | 79.09 | 0.02 | 3.10 | 0.85 | 0.10 | 0.06 | 1.02 |
| PERQ9 | Average | 3.91 | 0.99 | 16.60 | 75.77 | 0.03 | 3.98 | 0.63 | 0.10 | 0.04 | 0.65 |
|  | Min | 3.69 | 0.95 | 16.21 | 75.58 | 0.02 | 3.49 | 0.52 | 0.09 | 0.03 | 0.56 |
|  | Max | 4.25 | 1.07 | 17.17 | 76.00 | 0.03 | 4.26 | 0.69 | 0.12 | 0.04 | 0.75 |
| PERQ10 | Average | 6.88 | 0.40 | 15.81 | 73.60 | 0.03 | 3.56 | 1.11 | 0.13 | 0.06 | 1.19 |
|  | Min | 6.51 | 0.37 | 15.60 | 73.36 | 0.03 | 3.15 | 0.95 | 0.11 | 0.05 | 1.00 |
|  | Max | 7.37 | 0.45 | 16.33 | 73.96 | 0.03 | 3.75 | 1.20 | 0.14 | 0.06 | 1.28 |
| PERQ11 | Average | 6.92 | 0.38 | 15.74 | 73.54 | 0.03 | 3.63 | 1.13 | 0.13 | 0.06 | 1.21 |
|  | Min | 6.68 | 0.36 | 15.58 | 73.31 | 0.03 | 3.24 | 0.97 | 0.11 | 0.05 | 1.03 |
|  | Max | 7.39 | 0.42 | 16.22 | 73.71 | 0.04 | 3.75 | 1.20 | 0.14 | 0.06 | 1.27 |
| PERQ12 | Average | 4.79 | 1.20 | 16.73 | 74.65 | 0.03 | 3.59 | 0.75 | 0.12 | 0.05 | 0.81 |
|  | Min | 4.61 | 1.11 | 16.45 | 74.04 | 0.03 | 3.16 | 0.63 | 0.10 | 0.04 | 0.68 |
|  | Max | 5.21 | 1.33 | 17.26 | 74.93 | 0.03 | 3.80 | 0.82 | 0.14 | 0.05 | 0.89 |

The Na2O concentrations in Turkish perlites varied from 3.30 (perlite sample from PERQ4) to 8.51% (perlite sample from PERQ8) with a mean of 5.94%. The average Na2Oconcentration is approximately 2 times higher than the average value of Earth's continental crust of 2.66% (Yaroshevsky 2006). The highest Na2O concentration was analyzed in the PERQ5. The average Na2Oconcentrations in perlite quarries are summarized in descending order as follows: PERQ5 > PERQ2 > PERQ6 > PERQ11 > PERQ10 > PERQ7 > PERQ8 > PERQ4 > PERQ12 > PERQ1 > PERQ3 > PERQ9.

The K2O concentrations in Turkish perlites varied from 2.02 (perlite sample from PERQ4) to 4.27% (perlite sample from PERQ1) with a mean of 3.49%. The average K2Oconcentration is approximately 3 times higher than the average value of Earth's continental crust of 1.09% (Yaroshevsky 2006). The highest K2O concentration was analyzed in the PERQ3. The average K2O concentrations in perlite quarries are summarized in descending order as follows: PERQ3 > PERQ1 > PERQ9 > PERQ11 > PERQ12 > PERQ10 > PERQ2 > PERQ7 > PERQ6 > PERQ5 > PERQ8 > PERQ4.

The Fe2O3 concentrations in Turkish perlites varied from 0.56 (perlite sample from PERQ9) to 1.35% (perlite sample from PERQ6) with a mean of 0.94%. The average Fe2O3 concentration is lower than the average value of Earth's continental crust of 1.11% (Yaroshevsky 2006). However, the average Fe2O3 concentrations analyzed in perlite samples from PERQ6, PERQ11, PERQ10, and PERQ3 are slightly higher than the average value of Earth's continental crust. The highest Fe2O3 concentration was analyzed in the PERQ6. The average Fe2O3 concentrations in perlite quarries are summarized in descending order as follows: PERQ6 > PERQ11 > PERQ10 > PERQ3 > PERQ2 > PERQ1 > PERQ12 > PERQ8 > PERQ7 > PERQ5 > PERQ4 > PERQ9.

The CaO concentrations in Turkish perlites varied from 0.25 (perlite sample from PERQ5) to 1.20% (perlite sample from PERQ10) with a mean of 0.71%. The average CaOconcentration is lower than the average value of Earth's continental crust of 9.41% (Yaroshevsky 2006). The highest CaO concentration was analyzed in the PERQ11. The average CaO concentrations in perlite quarries are summarized in descending order as follows: PERQ11 > PERQ10 > PERQ6 > PERQ3 > PERQ12 > PERQ8 > PERQ2 > PERQ4 > PERQ9 > PERQ7 > PERQ1 > PERQ5.

The MgO concentrations in Turkish perlites varied from 0.05 (perlite sample from PERQ5) to 1.33% (perlite sample from PERQ12) with a mean of 0.56%. The average MgOconcentration is lower than the average value of Earth's continental crust of 5.44% (Yaroshevsky 2006). The highest MgO concentration was analyzed in the PERQ12. The average MgO concentrations in perlite quarries are summarized in descending order as follows: PERQ12 > PERQ9 > PERQ4 > PERQ8 > PERQ1 > PERQ3 > PERQ10 > PERQ11 > PERQ7 > PERQ6 > PERQ2 > PERQ5.

The TiO2 concentrations in Turkish perlites varied from 0.02 (perlite sample from PERQ2) to 0.14% (perlite sample from PERQ11) with a mean of 0.09%. The average TiO2 concentration is lower than the average value of Earth's continental crust of 0.97% (Yaroshevsky 2006). The highest TiO2 concentration was analyzed in the PERQ11. The average TiO2 concentrations in perlite quarries are summarized in descending order as follows: PERQ11 > PERQ10 > PERQ12 > PERQ9 > PERQ6 > PERQ3 > PERQ1 > PERQ8 > PERQ4 > PERQ7 > PERQ5 > PERQ2.

The MnO concentrations in Turkish perlites varied from 0.03 (perlite sample from PERQ3) to 0.07% (perlite sample from PERQ5) with a mean of 0.05%. The average MnOconcentration is lower than the average value of Earth's continental crust of 0.16% (Yaroshevsky 2006). The highest MnO concentration was analyzed in the PERQ11. The average MnO concentrations in perlite quarries are summarized in descending order as follows: PERQ11 > PERQ10 > PERQ5 > PERQ7 > PERQ6 > PERQ8 > PERQ2 > PERQ4 > PERQ12 > PERQ1 > PERQ3 > PERQ9.

The P2O5 concentrations in Turkish perlites varied from 0.01 to 0.04% with a mean of 0.02%. The average P2O5 concentration is lower than the average value of Earth's continental crust of 0.19% (Yaroshevsky 2006). The highest P2O5 concentration was analyzed in the PERQ11. The average P2O5 concentrations in perlite quarries are summarized in descending order as follows: PERQ11 > PERQ10 > PERQ12 > PERQ6 > PERQ3 > PERQ9 > PERQ1 > PERQ7 > PERQ4 > PERQ8 > PERQ5 > PERQ2.

**3.2. Alkaline earth metals of perlite samples**

The average and range (min-max) values of alkaline earth metals analyzed in all perlite quarries are given in Table 6. From Table 6, alkaline earth metals analyzed in perlite samples are ranked in descending order as follows: Ca > Mg > Ba > Sr according to their average concentration.

The Ca concentrations in the perlite samples varied from 1752 to 12030 mg/kg with an average value of 5099 mg/kg, which is lower than the Earth's continental crust average of 29600 mg/kg (Yaroshevsky 2006). The highest Ca concentration was analyzed in the PERQ11. The average Ca concentrations in perlite quarries are summarized in descending order as follows: PERQ11 > PERQ10 > PERQ6 > PERQ3 > PERQ12 > PERQ8 > PERQ2 > PERQ4 > PERQ9 > PERQ7 > PERQ1 > PERQ5.

The Mg concentrations in the perlite samples varied from 313 to 8044 mg/kg with an average value of 3373 mg/kg, which is lower than the Earth's continental crust average of 18700 mg/kg (Yaroshevsky 2006). The highest Mg concentration was analyzed in the PERQ12. The average Mg concentrations in perlite quarries are summarized in descending order as follows: PERQ12 > PERQ9 > PERQ4 > PERQ8 > PERQ1 > PERQ3 > PERQ10 > PERQ11 > PERQ7 > PERQ6 > PERQ2 > PERQ5.

## Table 6. Concentrations of alkaline earth metals in perlite quarries

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample code |  | Concentration of alkaline earth metals (mg/kg) | | | |
| Mg | Ca | Sr | Ba |
| PERQ1 | Average | 2534.7 | 2544.4 | 6.6 | 35.3 |
|  | Min | 2446.0 | 2100.0 | 5.9 | 20.9 |
|  | Max | 2643.0 | 2912.0 | 7.6 | 48.3 |
| PERQ2 | Average | 919.7 | 4878.1 | 16.3 | 46.4 |
|  | Min | 818.0 | 4179.0 | 13.8 | 31.4 |
|  | Max | 1102.0 | 5218.0 | 18.3 | 64.2 |
| PERQ3 | Average | 2446.9 | 5514.9 | 15.7 | 101.7 |
|  | Min | 1999.0 | 3750.0 | 12.9 | 87.9 |
|  | Max | 2786.0 | 6449.0 | 17.8 | 118.9 |
| PERQ4 | Average | 5964.7 | 4717.9 | 26.3 | 214.9 |
|  | Min | 3791.0 | 3756.0 | 20.7 | 201.5 |
|  | Max | 7303.0 | 5541.0 | 31.8 | 237.6 |
| PERQ5 | Average | 462.4 | 2032.6 | 6.6 | 41.5 |
|  | Min | 313.0 | 1752.0 | 4.7 | 23.2 |
|  | Max | 634.0 | 2317.0 | 9.5 | 74.3 |
| PERQ6 | Average | 1037.0 | 6692.8 | 59.7 | 350.4 |
|  | Min | 961.0 | 5637.0 | 49.0 | 284.3 |
|  | Max | 1105.0 | 7088.0 | 63.7 | 384.2 |
| PERQ7 | Average | 1294.4 | 2818.3 | 17.8 | 157.6 |
|  | Min | 1175.0 | 2457.0 | 15.1 | 140.8 |
|  | Max | 1446.0 | 3144.0 | 19.5 | 187.2 |
| PERQ8 | Average | 3239.5 | 4957.5 | 32.6 | 194.6 |
|  | Min | 2694.0 | 3810.0 | 23.2 | 154.1 |
|  | Max | 3533.0 | 6109.0 | 43.1 | 237.7 |
| PERQ9 | Average | 5982.5 | 4478.9 | 83.9 | 1764.4 |
|  | Min | 5735.0 | 3728.0 | 68.7 | 1244.0 |
|  | Max | 6469.0 | 4933.0 | 94.7 | 2042.0 |
| PERQ10 | Average | 2538.3 | 8310.5 | 85.5 | 517.4 |
|  | Min | 2218.0 | 6769.0 | 68.8 | 438.7 |
|  | Max | 3915.0 | 12030.0 | 107.0 | 565.2 |
| PERQ11 | Average | 2319.2 | 8067.0 | 86.4 | 525.9 |
|  | Min | 2186.0 | 6953.0 | 72.0 | 407.5 |
|  | Max | 2535.0 | 8555.0 | 91.2 | 577.9 |
| PERQ12 | Average | 7224.1 | 5375.2 | 100.5 | 1490.9 |
|  | Min | 6705.0 | 4529.0 | 80.5 | 1050.0 |
|  | Max | 8044.0 | 5890.0 | 109.3 | 1701.0 |

The Sr concentrations in the perlite samples varied from 5 (perlite sample from PERQ5) to 109 mg/kg (perlite sample from PERQ12) with an average value of 50 mg/kg, which is lower than the Earth's continental crust average of 340 mg/kg (Yaroshevsky 2006). The highest Sr concentration was analyzed in the PERQ12. The average Sr concentrations in perlite quarries are summarized in descending order as follows: PERQ12 > PERQ11 > PERQ10 > PERQ9 > PERQ6 > PERQ8 > PERQ4 > PERQ7 > PERQ2 > PERQ3 > PERQ1 > PERQ5.

The Ba concentrations in the perlite samples varied from 21 (perlite sample from PERQ1) to 2042 mg/kg (perlite sample from PERQ9) with an average value of 569 mg/kg, which is lower than the Earth's continental crust average of 650 mg/kg (Yaroshevsky 2006). The highest Ba concentration was analyzed in the PERQ9. The average Ba concentrations in perlite quarries are summarized in descending order as follows: PERQ9 > PERQ12 > PERQ11 > PERQ10 > PERQ6 > PERQ4 > PERQ8 > PERQ7 > PERQ3 > PERQ2 > PERQ5 > PERQ1.

**CONCLUSIONS**

The study is the first detailed research on the determination of oxides and alkaline earth metals in perlite samples obtained from 12 perlite quarries located in different provinces of Türkiye. The results of this study provide guiding information for the more effective and efficient use of perlite minerals in different sectors.

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