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Distribution of Natural Radioactivity from ^{40}K Radioelement in Volcanics of Sandıklı-Şuhut (Afyon) Area

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Many radioactive elements have existed when the Earth had appeared and the long living of them are still present. One of the most important of these radioactive elements is ^{40}K. It makes about 0.012% of total content of K, widely represented in many different rocks. In this study the distribution of the natural ^{40}K radioelement in the volcanics of the south part of Afyon was investigated. Gamma-ray spectrometer was used for in-situ measurements of this radioelement concentration. Studied area has covered approximately 1800 km^2. In-situ measurements were performed at 1390 different locations in this field. Data for each measurement was gathered during 3 min. The map of the ^{40}K element distribution in the studied area was produced. The high values of ^{40}K, according to this map, were obtained in the areas of the alteration zones, between Sandıklı and Şuhut in the studied area.

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1. Introduction

The spectrum of gamma-ray energies allows to determine the concentration of individual elements like K, eU and eTh. Thus it is possible to map rocks by means of their characteristic radioelement signatures. There is a lot of work for mapping, exploration and environmental studies [1–8]. The ^{40}K concentration, determined by gamma-ray spectrometry, is also used to define the relationship between geological settings and alteration. For example, sericitization which is of potassic alteration type, is commonly connected with many types of volcanic rock, associated with massive-sulfide, base-metal and gold deposits [9, 10]. Many alkaline and calc-alkaline porphyry Au-Cu deposits have wide potassic hydrothermal alteration anomalies [11, 12]. Potassium alteration is widespread in shear-hosted gold deposits [13–15]. Moxham et al. [16] emphasized that the amount of potassium increases two-fold in alteration zones where there are copper (Cu), lead (Pb) and zinc (Zn). These minerals can be indirectly determined by looking at the potassium concentration map.

^{40}K isotope decays into ^{40}Ar with the emission of gamma-rays with energy of 1.46 MeV. In this study, gamma-photons were counted using 1024-channel gamma-ray spectrometer. ^{40}K concentration was automatically calculated using these measurements. Finally, ^{40}K concentration map was created to provide direction for exploration and environmental studies.

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2. Material and method

The studied region is located in Isparta Angle between 38.04857 °N and 39.19543 °N latitude and 30.00363 °E and 30.03338 °E longitude and has approximately 1800 km^2 of surface area. The highest point of the study area is at Kumalar Mountain which is 2447 m above the sea level. The area runs north-to-south between Sandıklı and Şuhut. Afyon volcanics are commonly observed in the east and northeast of Sandıklı. These volcanics are represented by lavas, tuffs and tuffite levels. Starting in the Middle Miocene, and continuing in the Upper Miocene, volcanic activity has produced volcanic material, transported in flows to the lake environment. Especially, tuff and tuffite (lacustrine tuff) are widely observed in the east of the Akın and Kargın villages [17]. As a result of the geological observations in this project, supported by TÜBİTAK, Tertiary volcanism in the studied area is divided into three phases.

In phase I the calc-alkaline magmatism had occurred (formation of syenodiorite porphyroid and its associated trachyandesitic and trachytic products).

In phase II the trachyte, trachyandesite, andesite, trachybasalt types of volcanic rocks and their pyroclastics had occurred.

In phase III the ultra potassic rocks like tephrite, phonolite, leucitits, leucit basalt had occurred by alkaline magmatism. In addition, debris flows had occurred in the form of pyroclastic rocks.

Intense alterations were studied by Gündoğan et al. [18] in Northeast of Sandıklı. In this region, there is the intrusion of syenit-syenodiorite composition. These alterations, associated with the hydrothermal fluids, develop depending on the intrusion type.

Neogene and Quaternary alluvium, and Paleozoic metamorphic rocks, except for commonly observed volcanics, are also present in the studied area (Fig. 1).

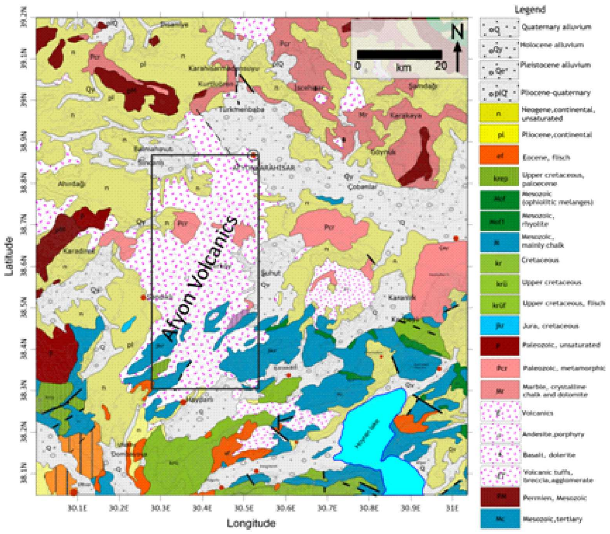

Fig. 1. Geological map of Afyon and its surroundings (Modified from MTA, 1963 [19]) and the location of the studied area.

2.1. Portable gamma-ray spectrometry

Portable hand-held gamma-ray spectrometers are widely used in field studies. Portable gamma-ray spectrometers, utilized for natural radioelement mapping, monitor the energy channels centered at 1461 keV (^{40}K), 1765 keV (^{214}Bi) and 2615 keV (^{208}Tl) photopeaks, for the estimation of K, U and Th concentrations, respectively [20, 21].

In this study, portable gamma-ray spectrometry was used for mapping of the surface concentration of the natural radioelements. 1024-channel spectrometer with BGO detector was used for in-situ measurements. Working principle of the spectrometer is based on capture of gamma-rays in perfect quality bismuth germanium oxide (BGO) detector, with connected 1024-channel spectral analizer. Calibration of the spectrometer is performed using great volume K, U, Th and background standards, according to IAEA (International Atomic Energy Agency) recommendation.

2.2. Mapping of ^{40}K concentration and assessment

In this study, measurements were made using a portable gamma-ray spectrometer at 1390 measurement points. Measurement time was three minutes. Location of each measurement was obtained using GPS. The GPS data were transferred to spectrometer via a cable. Ultimately, the GPS and radioactivity data at each point were recorded by gamma-ray spectrometer. Concentration map of the potassium was created using the obtained data. While activity concentration of ^{40}K changes between 0 and 7% in the studied area (Fig. 2), it varies between 2–7% for Afyon volcanics. The obtained ^{40}K concentration values, corresponding to each volcanic phase, are in the range of 6–7%, 4–6%, 2–4%, respectively. Concentration values in the 0–2% range refer to limestone, sandstone, conglomerate and flysch.

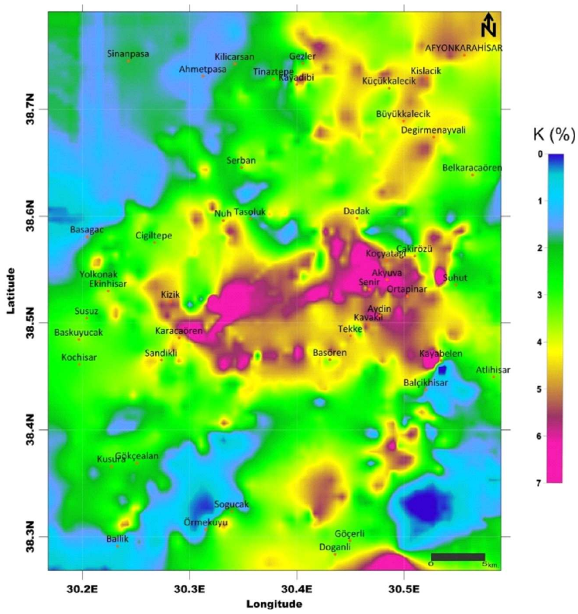

Fig. 2. ^{40}K concentration map of Afyon volcanics.

3. Conclusions

The wide range of ^{40}K concentrations is possible to separate into three groups. These groups can also be matched with the three phase volcanic. Intense alterations (silicating, iron oxide, sulfur and so on) which accompany the first stage of volcanism, have led to an increase in ^{40}K concentration in volcanic rocks. Potassium anomaly on the concentration map indicates presence of the alterations and the associated mineralizations.

Acknowledgments

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