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Evaluation of U-Th enrichments in QGIS platform; Example of Arıklı (Çanakkale, Turkey) district

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Abstract

Uranium (U) and Thorium (Th) are strategically important elements worldwide. For this reason, exploring these elements, which are enriched in many geological environments, is exceedingly significant. U-Th enrichments in Turkey were usually discovered in the Western Anatolian geography. U-Th anomalies were still observed in the Arıklı region south of Çanakkale. In this study, remote sensing and Geographical Information Systems (GIS) were utilized in the QGIS program to carry out the geochemical data obtained in the field more understandable. U-Th values, which show high values in the fault zones in the Arıklı region, are immediately related to the CaO values. As in many geological studies, remote sensing and GIS studies suggest the opportunity to check out field data with a significant quality in exploring ore deposits.

1. Introduction

Uranium and Thorium are significant and strategic radioactive elements. For this reason, applications are carried out to explore these elements, which are enriched in many geological environments. Granite and volcanic rocks are essential sources of Uranium enrichment (Zhang and Zhang 1991; Qin and Liu 1998). U deposits are divided into four groups corresponding to the host rock lithology (Li et al. 2002). These are granite-rock type (G-type), sandstone type, volcanic-rock type (V-type), and carbonaceous-silica-pelitic-rock type (CSP-type), respectively. It has been described that the significant uranium enrichments in Turkey are situated in western Anatolia (Şaşmaz 2008).

MTA started uranium exploration activities in Turkey in 1953, and after that, exploration studies continued (Contencin 1960; Günaydın 2017). In the Ayvacık-Küçükkuyu field near Çanakkale province, the U3O8 value was 0.08% in Miocene carbonate rocks (MTA, 2009, MTA 2010c). There are phosphate nodules and natural radiation sources in the volcanic tuffs between Küçükkuyu and Ayvacık (Atabey 2006). On the Geyikli coast, near the region, there are minerals (taurite and uraninite) consisting of heavy metals, uranium and Thorium in the sands (Andaç 1971). These radioactive minerals originate from the granitic rocks outcropping around Geyikli (Andaç 1971). Günaydın (2017) explained that there is a U enrichment in the composition of bayleite and ningyoite in and around Arıklı. High natural radiation values were also reached in the fault zones around Örencik and Feyzullah Tepe, northwest of Arıklı (Atabey 2006). The effect of hydrothermal waters forms magnesite breccias located in the northwest of Arıklı, and there are U up to 700 ppm and Th greater than 1000 ppm in this fault zone (Günaydın 2017). Öztürk et al. (2021) examined microthermometric measurements from magnesite observed in these fault zones and determined that (Th, ^{o}C) was between 282-348 ^{o}C and % NaCl salinity equivalents were between 4.2-8.0. They also stated that the solution system of liquid inclusions is in the form of H_2O-$MgCl_2$-$CaCl_2$, and the density of liquids is between 0.58-0.74 g/cm^3.

In recent years, high-resolution digital applications have been widely used in geological studies. Remote sensing (RS) and geographic information systems (GIS) are principles for map-based interpretation of many geological structures. With scientific advances in spatial analysis techniques, linearity, ore exploration, and morphological investigations have become practical.

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Geographic Information Systems (GIS) have also been used in mineral exploration studies and mine probability maps (Porwall et al. 2001; Joly et al. 2012; Lindsay et al. 2014).

This study evaluated the analysis results obtained in the survey by Öztürk et al. (2021). Samples collected in the field, geological maps, satellite images and thematic maps were evaluated together.

2. Method

The DEM image of this geologically significant region has been downloaded from the United States Geological Survey (USGS) website. Aspect, 3D map and slope map of the region was created by evaluating the downloaded images in the QGIS environment. The geological map prepared by Öztürk et al. (2021) was digitized in the GIS environment, and sample points were located. Afterwards, heat maps dwelling on major oxide and trace elements were made.

2.1. Regional Geology

The application area is south of the Biga Peninsula in Western Anatolia. The application area in the Ayvacık district of Çanakkale is tectonically located in the Sakarya Zone (Fig 1). Okay et al. (1990) described the units in the Çanakkale region as pre-tertiary and post-Tertiary units, respectively. Their subsequent studies divided it into three pre-tertiary tectonic zones observed in the NE-SW direction (Okay et al. 2001; Okay and Altıner 2004). These zones are Ezine Zone, Ayvacık-Karabiga Zone and Sakarya Zone respectively.

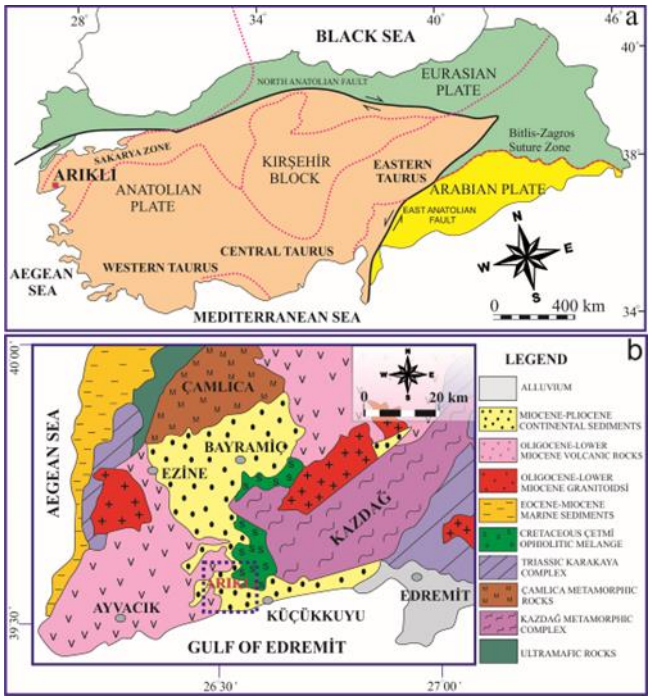

Figure 1. a. Tectonic location of the study area (modified from Işık 2016), b. Generalized geology map of the Biga region and location of the study area (modified from Okay and Satır 2000a; Şengün et al. 2011).

Many metamorphic facies and magmatic, ophiolite, sedimentary and volcanic rock groups are established north of the Gulf of Edremit (Fig 1) (Okay and Satır 2000a; Şengün et al. 2011). In the vicinity of Arıklı, the Miocene Pliocene aged continental sediments and Cretaceous aged Çetmi melange are outcrop (Fig 1).

The Cretaceous Aged Çetmi Ophiolitic Melange, Küçükkuyu Formation and Quaternary aged alluvial deposits are located in the study area. In the Küçükkuyu formation, shale-sandstone member and Arıklı tuff member were separated, and diabases that cut these units were mapped on the Örencik Tepe (Fig 2).

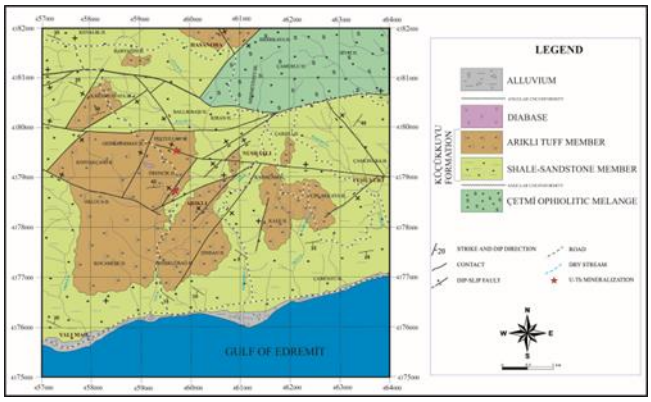

Figure 2. Geological map of the study area.

3. Results

3.1. Ore Geochemistry

Öztürk et al. (2021) collected 48 samples in the field. XRF and ICP-MS methods analyzed these collected samples in Istanbul Technical University Geochemistry Research Laboratory (ITU-JAL). Corresponding to the results of the analysis, U and Th anomalies are observed in the dip-slip fault zones. U is between 64-1640 ppm in these fault zones, and Th is between 302-11813 ppm, respectively. As a result of these data, U and Th mineralizations in the region are related to fault zones observed in Arıklı ignimbrites.

3.2. Remote Sensing

Topographical approaches were obtained with the DEM image of Arıklı and its vicinity. The downloaded DEM images were evaluated in the QGIS environment, an open-source Geographical Information System.

The images of the region generally obtained by remote sensing were evaluated in the QGIS environment. DEM data was classified and coloured in the QGIS environment with a single band pseudocolour application. Then 3D map of the region was created to obtain a more understandable image (Fig 3).

3.3. GIS Application

Sample points of major oxide and trace elements are yielded in Fig 4. Heat maps were established corresponding to spatially major oxide and trace element values appropriately. CaO and U-Th enrichments are observed strongly in similar areas, and a direct ore-fault- and lithology relationship is observed. There are U-Th enrichments exclusively in CaO-rich and faulted areas. This relationship still shows pretty usefully in the GIS environment.

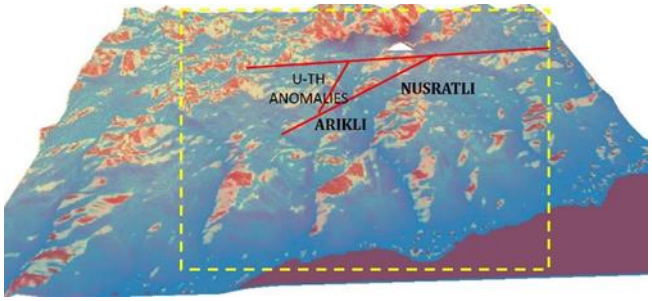

Figure 3. 3D-map of the study area and surroundings

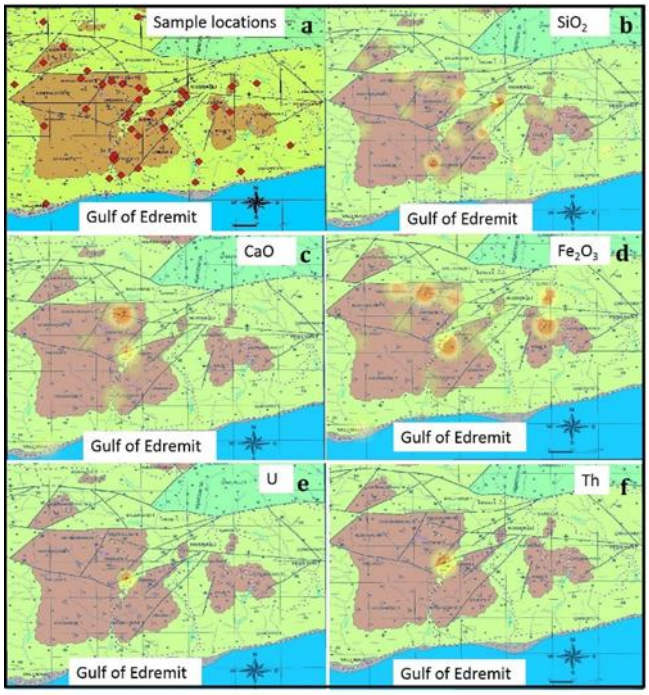

Figure 4. GIS applications of the study area.

4. Discussion and Conclusion

Many GIS-based applications have been carried out in uranium exploration studies. On the principle of these, GIS-based modelling has been proposed in addition to geology-geochemistry studies (Brown et al. 2003; Partington 2008).

Mapping minerals, elements or oxides based on multi-source geoscience data (geology, geochemistry, and remote sensing) and computer technology is an effective technique that merges information and data-driven production (Bonham-Carter 1994; Zhao 2002; Cheng et al. 2007; Asadi. et al. 2016; Ford et al. 2016; Wang et al. 2016). For this reason, the data of the study conducted by Öztürk et al. (2021) in the Arıklı region were re-evaluated in the QGIS environment. Field data, remote sensing and GIS data were correlated. In the evaluations prepared, field and spatial data are consistent and supported by thematic maps.

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