Applied Radiation and Isotopes 121 (2017) 109–115

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Thermoluminescence behavior of basaltic rocks collected in southeastern region of Turkey

Dilek Toktamış, Hüseyin Toktamış*, A.Necmeddin Yazıcı

University of Gaziantep, Department of Engineering Physics, 27310 Gaziantep, Turkey

ARTICLE INFO

Keywords:
Thermoluminescence
Basalt
Volcanic rock
Annealing

ABSTRACT

Basalt is well known as an extrusive igneous rock erupts on land by volcanic eruption. It is darker, denser and finer grained compared to the familiar granite of the continents. The study reveals the thermoluminescence properties (TL) of basaltic rocks which collected in southeastern region of Turkey. With this study, the variations of glow curve of the basalt at the different grain sizes, different annealing temperature and different annealing time have been investigated. This study also includes, dose response and heating rate experiments. As a result, the basalt sample shows thermoluminescence properties with a wide peak about 200 °C. The best TL sensitivity was observed at samples whose grain size is ~100 μm. The basalt sample has a wide TL glow curve. A linearity for the values up to 155 Gy and supralinearity between 155 Gy and 615 Gy in dose response are observed and it reaches to saturation beyond 615 Gy. Thermal treatments at higher temperatures decrease the TL sensitivity.

1. Introduction

Basalt is a very common igneous rock in the Earth's crust. It is a dense-looking, black rock, often weathering to a brown color, and is the commonest of all lavas. It is estimated that the basalt flows of the world have five times the volume of all other extrusive rocks together (De Freitas and Blyth, 1984). Almost all oceanic crust is made of basalt and basalt is a common extrusion from many volcanic regions around the world. It is formed as the volcanic magma erupts onto the surface or even in the water and undergoes a rapid cooling process. It has varying shades of grey to black. The fast cooling process makes the creation of the minerals almost invisible, making it a fine-grained substance. Basalt is the rock that is the most plentiful in the crust of the Earth. It can also be found in the Moon, Venus, Mars and several asteroids. The ocean floor is generally made up of basalt rock. Basalt also comes from extensive lava flows. Basalt lava can flow easily and quickly across great distances delivering great volumes of basaltic rock. Some of these extrusions covered huge areas of the Earth.

Basalt has no harmful properties, non-explosive and noncombustible. It is used for a lot of purposes such as road base, concrete aggregate, asphalt pavement aggregate, railroad ballast, filter stone in drain fields and may other purposes. Essential minerals in the basalt are plagioclase and augite. The basalt samples used in the study of Çanakci and Pala (2007) consisting of a 50–60% plagioclase, 25–30% olivin and 2–25% calcite. The region of basalt samples of our study is same with Canakci et al. (Çanakci and Pala, 2007). Plagioclase is a group of feldspar minerals that form a solid solution series from albite (sodium aluminum silicate) to anorthite (calcium aluminum silicate). The normal feldspar of basalts is labradorite, but andesine, olioglase, or albite may occur in different varieties.

Several studies (Çanakci and Pala, 2007; Al-Harthi et al., 1999; Gupta and Seshagiri, 2000; Militky et al., 2002; Moore, 2001; Pan et al., 1998; Bell and Haskins, 1997) about engineering applications of basalt have been done except for luminescence studies (Morthekai et al., 2008; Aparicio and Bustillo, 2012; Tsukamoto and Duller, 2008; Huntley and Lian, 2006; Kayama et al., 2013; Correcher et al., 2004).

Correcher et al. (2004) used basaltic samples of a lava flow from Poas volcano (Costa Rica) in their study to determine the kinetic parameters of both natural and induced TL curves of a basaltic rock (polymineral phase) due to a continuous distribution of trapping centers.

Morthekai et al. (2008) have been studied that the anomalous fading of trapped charge in basalt and andesite rock samples. They concluded that optically stimulated luminescence (OSL) signals show rapid fading (of between 4% and 27% per decade). Fading rates obtained using high temperature thermoluminescence signals are smaller.

Another study concerned of basaltic sample has been done by Tsukamoto and Duller (2008). Their study was about the fading rates (*g*-values) of various luminescence signals using four samples of basalt. It was found that the fading rate was larger in the samples containing olivine, pyroxene and plagioclase phenocrysts and smaller in glassy

* Corresponding author.
E-mail address: toktamis@gantep.edu.tr (H. Toktamış).

http://dx.doi.org/10.1016/j.apradiso.2016.12.051
Received 27 June 2016; Received in revised form 12 December 2016; Accepted 28 December 2016
Available online 29 December 2016
0969-8043/

samples. Fading rates of plagioclases and alkali feldspars was studied by Huntley and Lian (2006) and concluded that there was a positive correlation between fading rate and calcium content for plagioclase feldspars. Besides, Akber and Prescott (1985) stated the higher-Ca plagioclases usually show anomalous fading. A study about cathodoluminescence of plagioclase was done by Kayama et al. (2013) to see effects of He^+ ion implantation and electron irradiation. One of their results is electron irradiation causes Na^+ migration in plagioclase, and then a considerable reduction in intensity of emissions assigned to impurity centers, which is responsible for an alteration in the energy state or a decrease in luminescence efficiency following the change of activation energy.

2. Samples and methods

2.1. Samples and preparation

In the present study, basaltic rock samples were collected in Karataş region of Gaziantep which located in southeastern region of Turkey.

Large volume of basalt deposits dominantly exists in few areas of the Gaziantep, especially Karataş region. The basalt used in this study was generally formed by flow of lava. There are different ideas about the formation of this lava. Some groups explain this lava flow with the East Anatolian Fault and other faults related to main fault. Others explain it with the tectonic movements activated during Middle Miocene (Çanakcı et al., 2002). Basalt found in the area named as Yavuzeli basalt by Yoldemir (1987).

As a result of XRD analysis of the basaltic rocks obtained from XRD Facility of Bogaziçi University Advanced Technologies R & D Center, a Rigaku D/MAX-Ultima + /PC X-ray diffraction equipment shown in Fig. 1, the main minerals of the sample are plagioclase minerals that form a solid solution series from albite (sodium aluminum silicate) to anorthite (calcium aluminum silicate), cristobalite and quartz seen in Table 1.

The collected basaltic rocks in the field were crushed using agate mortar and washed in HCl acid to eliminate organic residues (Vaijapurkar et al., 1998; Teixeira and Caldas, 2004; Fleming, 1970). Then, they were washed with pure water several times and dried in an oven at 50 °C. They were sieved with using fine sieves whose have different dimensions from 50 to 400 μm. Finally, each sample was weighted 20 mg for each measurement.

Table 1
The analysis of XRD measurement of the powdered basaltic rock.

2 θ	d (Å)	Height %	Phase ID	*hkl*
22,983	3,8664	15,5	Albite	(1–1 1)
23,840	3,7293	59,3	Anorthite sodian	(−1 3 0)
24,603	3,6154	56,6	Anorthite sodian	(−1–3 2)
26,660	3,3409	32,3	Quartz	(0 1 1)
27,995	3,1845	100,0	Anorthite sodian	(0 0 4)
28,636	3,1148	17,7	Cristobalite	(1 1 1)
35,200	2,5475	51,8	Anorthite sodian	(−2–4 2)
42,958	2,1037	39,8	Cristobalite	(2 1 1)
56,100	1,6381	20,8	Anorthite sodian	(4 2 1)
68,680	1,3655	35,0	Quartz	(0 3 1)

2.2. Equipments

2.2.1. Irradiation

All samples were irradiated at room temperature with a point beta source (^{90}Sr-^{90}Y) which delivers 0.040 Gy/s. The beta source installed in a 9010 optical dating system which is interfaced to a PC using a serial RS-232 port to control irradiation time and its activity is about 3.7GBq (100 mCi). It was purchased from Little More Scientific Engineering in UK and calibrated by manufacturer on March 10, 1994.

2.2.2. Reading

The glow curve measurements were made using a Harshaw TLD System 3500 Manual TLD Reader at 1 °C/s except heating rate experiment. The irradiated samples were read out in an N_2 atmosphere in order to avoid any undesired signals. A standard clear glass filter was always installed in the reader between the planchet and photomulti-

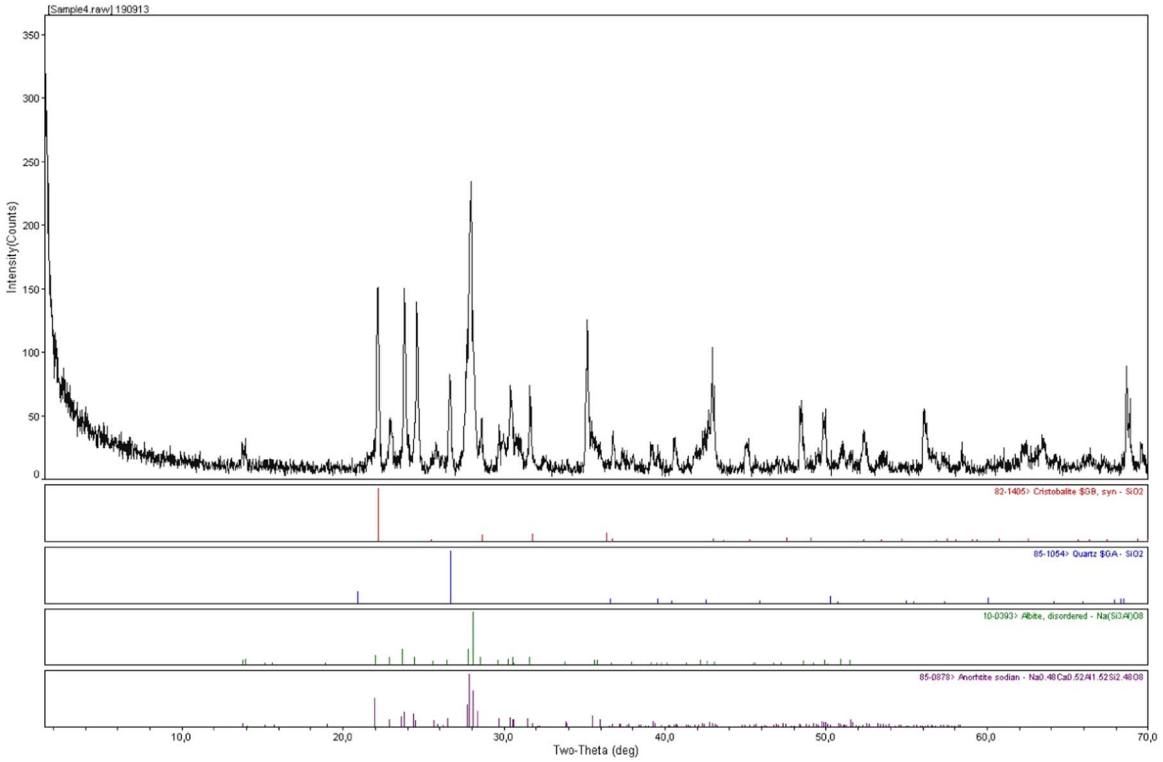

Fig. 1. The XRD measurement of powdered basaltic rock.