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Spectroscopic analysis of Ahlat stone (ignimbrite) and pumice formed by volcanic activity

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ABSTRACT

Natural materials such as ignimbrites are preferred commonly not only in historical places but also in houses or in different kind of buildings all over the world especially around Ahlat in Bitlis-Turkey. Durability, lightness and good-insulation are the significative properties of these stones. Also, pumice is an another preferred material because of its advantages in construction industry. In this paper, four kinds of ignimbrite (light-yellow, yellow, black and white) and pumice from Ahlat region have been investigated by EPR method to determine magnetic properties of them. The results obtained by EPR, EDS and XRD methods are evaluated together. SEM technique is also used to understand the surface morphology of the samples.

1. Introduction

Natural stones are widely used as construction materials all around the world. Ignimbrite is one of the most preferred material as building materials due to the fact that it can be obtained and processed easily and economically [1]. Natural stones can be classified as their minerology, formation conditions, physical and chemical properties. Atmospheric and environmental conditions are also effective on the structure of stones. Ignimbrites are pyroclastic flow rocks which are one of the volcanic rocks produced with volcanic eruptions. Pyroclastic flow rocks are composed of volcanic glass, pumice and lithic particles [1].

Nemrut Mountain is one of the volcanic centers in East Anatolian Volcanic Province. Nemrut is an important eruption center in Bitlis city and closest populated towns: Tatvan, Ahlat and Güroymak [2]. The Ahlat province is located in the eastern part of Turkey (composed of tectonic units), between the western part of the Lake Van and Nemrut volcano. About 100 km^3 volume of pyroclastic material were spreaded from Nemrut volcano and ignimbrites produced by this eruption have 30–50 m thickness in Bitlis valley [3,4].

Ignimbrite with its regional name of Ahlat stone is used extensively in various areas such as buildings, mosques, graveyard stones. In different studies, the ignimbrites are labeled by different colours. Ignimbrite levels with different colours separated by textures, structural features and welding degrees in the Ahlat region. The main effective properties for identification of ignimbrite types are welding degree and lithic components [1,4].

Another type of natural stone formed from volcanic activity is pumice. Pumice is a very porous glassy structured volcanic stone formed by leaving of the gas from the mass during sudden cooling in hot state magma and contains relatively high concentrations of silica, aluminum, and iron. Pumice brings many advantages due to its superior properties like its low density, high heat and noise insulation, air conditioning characteristic, easy plaster retaining, and elasticity in case of seismic load and behaviours [5,6]. Pumice has been also evaluated as a radiation shielding material in the previous studies [5,7].

Electron paramagnetic resonance (EPR) is a powerful magnetic resonance technique which enables determination of the local chemical environment of magnetically active nuclei ($I \neq 0$), paramagnetic species or radicals that have one or more unpaired electrons in their structure. EPR spectroscopy is interested in the spin transitions between the energy states in the presence of an external magnetic field, while they are degenerate in the absence of magnetic field. EDS is an analytical technique used to detect the elemental composition of a specimen by the interaction of some source of X-ray excitation and sample. XRD is one of the most preferred techniques to obtain information about the chemical composition and crystallographic structure of any crystalline material. With the aim of having knowledge in detail for determining near surface properties of samples SEM is used. SEM is an effective device for observing micro structure of surfaces [8].

It will be beneficial to distinguish and to define the regional petrographic and minerologic properties of natural materials because of the effect of local conditions on the formation of natural materials. So, authors have shown great interest on mechanical and physical properties, mineralogical and geochemical compositions of Ahlat ignimbrites in previous studies [4,9,10]. Also pumice has been studied by Nuhoglu et al. (2014) with EPR spectrometer but it is not clear from where the

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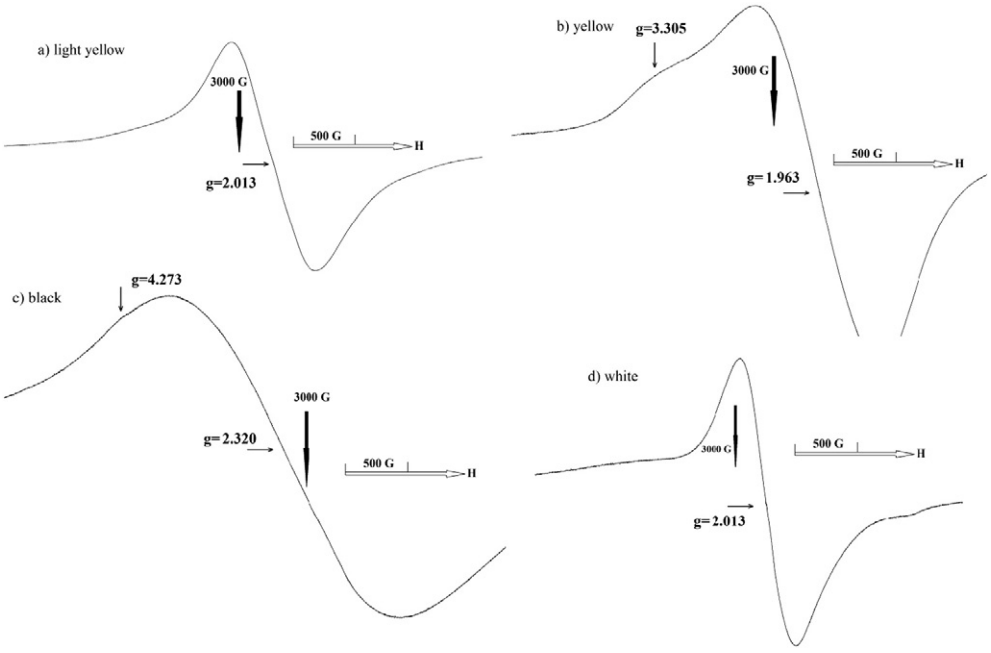

Fig. 1. EPR spectra of ignimbrites recorded at room temperature a) light-yellow b) yellow c) black d) white.

samples have been taken [5]. To our knowledge there is no EPR study about ignimbrite and pumice from Ahlat region. In this paper, our aim is to determine the magnetic properties of these ignimbrites and pumice with EPR method. By evaluating all the results together obtained with EPR, EDS, XRD and SEM techniques, the discussion on the issue of Ahlat stone and pumice will be shaped.

2. Experimental

Four types of ignimbrites known as Ahlat stone and pumice were provided from rock quarries present on the way of Bitlis-Ahlat road. All of the samples, light yellow; yellow; black; white and pumice, were crashed and their powder form were obtained. EPR spectra for powdered samples have been recorded by X-band EPR spectrometer (≈9.20 GHz) with 100 kHz modulation field at room temperature.

The XRD patterns of powdered ignimbrites and pumice samples were obtained by using Rigaku SmartLab XRD spectrometer, which was operated at 40 kV and 30 mA with a scanning speed of 5° min^{-1}. Cu Kβ radiation was used and data was taken for the 2θ range of 4°–90°.

In SEM technique, an electron gun with thermionic emission is usually used for producing electron. Obtained electrons are accelerated in high voltage (1–30 keV) and condenser lenses are used to demagnify electron beam until it has a diameter of approximately 10 nm. The signals composed because of the interaction between incident electron beam and sample give us different information about the specimen. The scanning electron microscope images of powders were measured by JEOL JSM-6610 SEM Spectrometer.

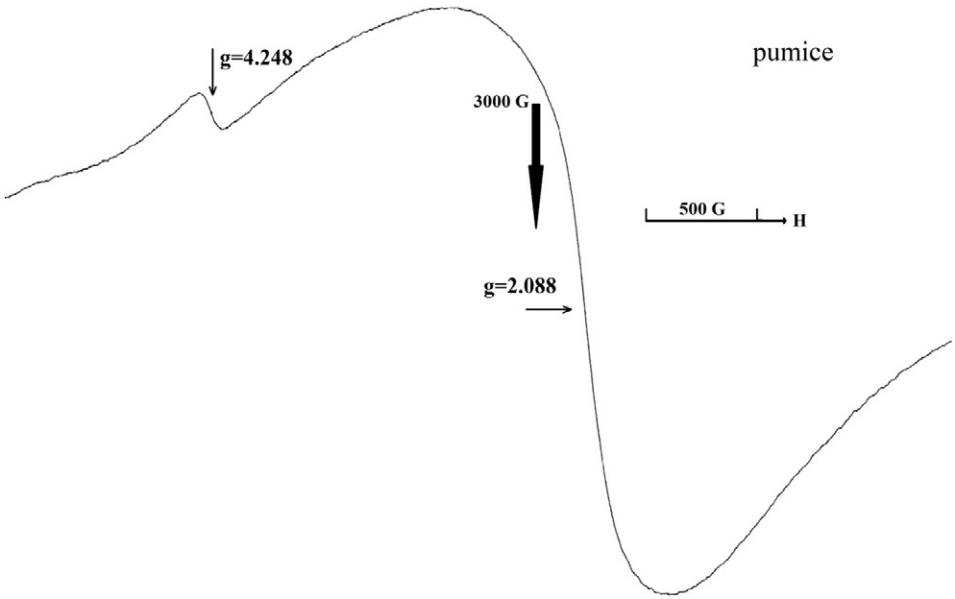

Fig. 2. An EPR spectrum of pumice recorded at room temperature.