ANALYSIS OF VOLCANO ROCK FROM CANARY ISLANDS

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Received 30 April 2013; accepted 09 May 2013

1. Introduction

Basalt rocks forms when lava reaches the Earth's surface at a volcano or mid ocean ridge. When the lava gets to the surface its temperature lies between 1100 and 1250°C. It cools quickly, within a few days or a couple weeks, forming solid rock. Basalt is an extrusive igneous rock that is very dark in colour. It is the most common type of rock in the Earth's crust and it makes up most of the ocean floor [1]. ^{57}Fe Mössbauer spectroscopy can be used for basalt rock study because of the abundance of iron in the dominant rock types. Mössbauer parameters yield information about the amount of iron at a particular site or in a particular oxidation state. Mössbauer spectroscopy can be an effective fingerprinting technique for the identification of different types of basaltic volcanic rocks. Mössbauer spectra of bulk samples of basalt can usually be analyzed in terms of components assigned to Fe^{2+} in pyroxenes ($(Mg,Fe,Ca)SiO_3$), olivine ($(Mg,Fe)_2SiO_4$), and a Fe(III) component attributed to ferric iron that is usually not possible to ascribe to any specific mineral species. Magnetic components include the pure iron oxides of spinel-type magnetite (Fe_3O_4) and maghemite (γ -Fe_2O_3) and the rhombohedral hematite (α-Fe_2O_3). In natural materials, impurities enter the structures, titanium being the most important one. The major primary magnetic mineral in ocean floor basalt is titanomagnetite ($Fe_{3-x}Ti_xO_4$), which undergoes progressive oxidation/maghemitisation during low temperature alteration to titanomaghemite that can generally be characterized as spinel with varying Ti/Fe ratio [2].

In this work we have analyzed the basalt rock from Lanzarote, which is the easternmost island of the Canary Islands lying in the Atlantic Ocean and has a volcanic origin. It was born through fiery eruptions and has solidified lava streams as well as extravagant rock formations. We compared our results with composition of basalt rocks from some other places on the Earth. Different iron oxides created on the volcanic rocks during their weathering on the Earth surface has been also analyzed.

2. Experimental Details

The samples were prepared in powder form scratching the very hard surface of the sample. Total sample weight was relatively small for some specimens, what prolonged recording of the Mössbauer spectra. All spectra were measured at room temperature using the standard Mössbauer spectrometer with the $^{57}Co(Rh)$ source. Mössbauer spectra were evaluated by CONFIT program. Each spectrum was fit with four distinct quadrupole doublets and two magnetic sextets. The relative areas of particular components are determined by the intensity and width of the absorption peaks and yield information about the amount of iron at particular sites.

3. Results and Discussion

Mössbauer spectrum of volcanic rock from Lanzarote island is shown in Fig.1. The spectrum consists of more components related to different iron-bearing phases of different contents. After evaluation process we found out that the magnetic fraction can be refined by two components and the non-magnetic fraction can be best fitted by four components. Values of average internal magnetic field induction of hyperfine magnetic splitting (H 1, H 2) and quadrupole splittings (QS 1, QS 2, QS 3,QS 4) of non-magnetic components are given in Tab.1.

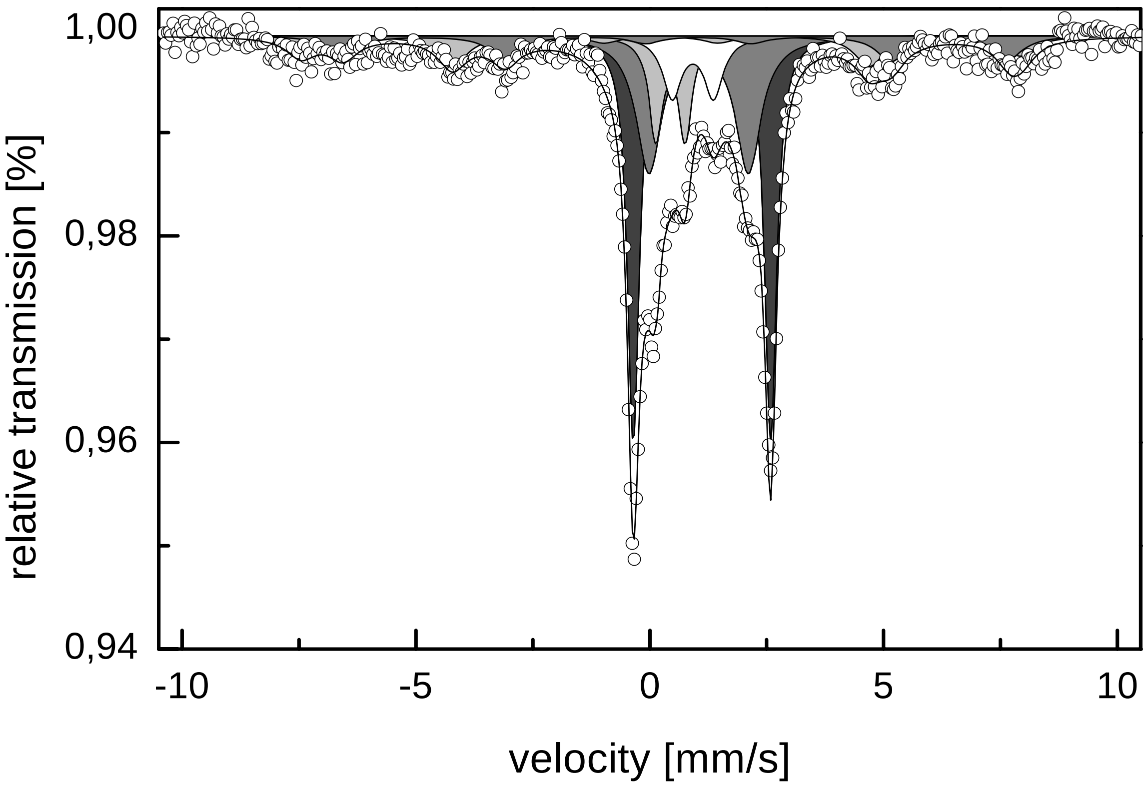

Fig.1: *Mössbauer spectrum of the volcanic sample from Lanzarote island.*

The doublet with quadrupole splitting of about 2.94 mm/s represents olivine, the doublet with QS of 2.13 mm/s corresponds to clinopyroxene. Both components contain iron in the form of Fe^{2+}. The third doublet with QS of 0.63 mm/s corresponds to Fe^{3+} site in clinopyroxene or to small particles of iron. The fourth component with QS of 0.88 mm/s represents ilmenite. Magnetic component includes iron oxides of spinel-type magnetite. According to the value of the hyperfine magnetic splitting, the magnetite contains some kind of impurities. In natural materials, impurities usually enter the structures and the most important is titanium. Values of hyperfine magnetic splitting indicate that magnetic component corresponds very close to titanomagnetite.

Comparing the relative fraction of the magnetic to the non-magnetic component, we found out that the relative amount of the magnetic part is much lower in comparison with the amount of the non-magnetic component (27% and 73%, respectively). The ratio of the Fe^{2+} to Fe^{3+} has been also determined and is equal 3.28, which indicate a stage of the oxidation process. If comparing this value with results from other basaltic rocks [3], it can be assumed that the oxidation was not strong.

Parameters of clinopyroxene are usually used for comparison of basalt volcanic rocks from different sources because each mineral phase will have a unique Mössbauer signature, depending on the location and bonding characteristics of the iron in the crystal structure. Comparison of the quadrupole splitings and isomer shifts of clinopyroxene from Mössbauer spectra analysis of samples from different locations is shown in Tab.2. As obvious from the values listed in the table, the parameters of the investigated sample from Lanzarote island correspond very closely to those of the other basaltic volcanic rocks. The differences have been, however, found in the intensity of the spectral lines and in the relative amount of the individual iron phases, which is typical for samples originating from different localities.

Tab. 1. *Parameters of Mössbauer spectra (MS) of volcanic sample from Lanzarote island (IS-Isomer shift, QS- quadrupole splitting, B- internal magnetic field, A- area of the subspectrum).*

Component	IS [mm/s]	QS [mm/s]	B[T]	A[%]
H1	0.24	0.00	47.8	12
H2	0.80	0.47	44.3	15
QS1	1.12	2.94	-	34
QS2	1.05	2.13	-	25
QS3	0.44	0.63	-	10
QS4	0.92	0.88	-	8

Tab. 2. *Comparison of Mössbauer spectra parameters of different basaltic rocks.*

Locality	Parameters		
	IS [mm/s]	QS [mm/s]	ref
QueenAnns. North Carol.	1.10	2.20	[1]
Lower Silesia, Poland	1.04	2.08	[3]
Mont Batur, Bali	1.10	2.02	[5]
Hawai	1.08	2.04	[4]
Lanzarote	1.05	2.13	this work

Beside Mössbauer spectroscopy technique, the sample has been analysed for basic elemental composition using the method of X-ray fluorescence analysis. X-ray fluorescence spectra were taken using Amptek X-123 Complete X-ray spectrometer and analysed by Amptek ADMCA program. The instrumentation system allows identifying elements with atomic number 11 and higher. The spectrum is shown in Fig. 2, where the peaks corresponding to the main constituent elements are signed. The spectrum analysis revealed that the major peaks correspond to characteristic radiation of iron (Fe Kα and Fe Kβ lines), as expected. In relatively high concentration can be found Ca comprised in pyroxene. Further elements identified in the spectrum were Ni, Ti, Si, Cu, Cr, Zn, K and Zr, from which Ti comes from titanomagnetite and Si is comprised in pyroxene and olivine. As the intensities of their characteristic X-ray lines are considerably lower in comparison with iron and calcium, the respective elements are supposed to be present in the sample in lower concentrations.

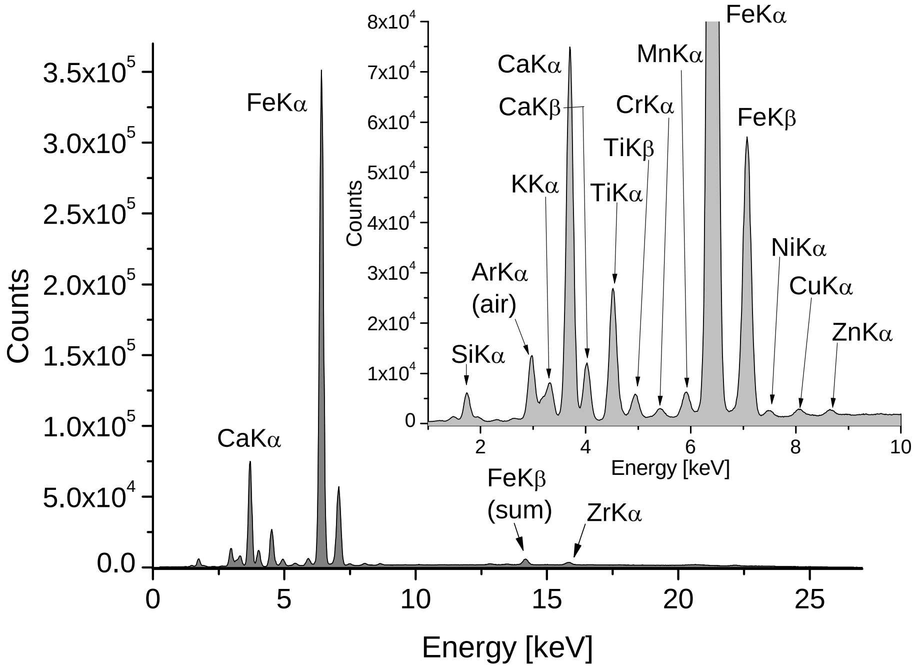

Fig. 2. *X-ray fluorescence spectrum of the volcanic rock from Lanzarote island.*

4.Conclusion

Basaltic volcanic rock sample from island Lanzarote was analysed by Mössbauer spectroscopy. In spite of the complexity of the spectrum, its similarity with other basaltic rocks from different localities was demonstrated. Some differences were, however, found in the intensity of the peaks. The combination of conventional geoscience methods and Mössbauer spectroscopy should allow the clear the detail distinction between particular rock types.

Acknowledgement

This work was financially supported by grant of Science and Technology Assistance Agency no. APVV-0516-10 and Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences No. VEGA-1/0286/12.

References:

[1] J.W. Miller, K.M. Whatley, J.E. Callahan, J.R. Craig: Southeastern Geology, **40**, 59 (2001).
[2] H.P. Gunnlaugsson, H. Rasmussen, L. Kritjanssan, S. Steinhorsson, O. Helgason, P. Norberg, M.B. Madson, S. Morup: Hyperfine Interaction, **182,** 87 (2008).
[3] N. Bakun-Czubarov, J. Galazka-Friedman, J. Suwalski, K. Szpila: Archivum Mineralogiczne, **49,** 3, (1993).
[4] D.C. Golden, R.V.Morris, D.W. Ming, H.V. Lauer, S.R. Yang: Journal of Geophysical research, **98,** 3401, (1993).
[5] J. Sitek, J. Dekan: *In: APCOM 2012. Applied Physics of Condensed Matter: Proceedings of the 18th International Conference, Štrbské Pleso, Slovak Republic,* 18.-20.6.2012. - Bratislava, STU, p. 71.