ANALYSIS OF VOLCANO ROCKS BY MÖSSBAUER SPECTROSCOPY

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Received 27 April 2012; accepted 30 April 2012.

1. Introduction

Basalt rocks forms when lava reaches the Earth's surface at a volcano or mid ocean ridge. The lava is between 1100 to 1250° C when it gets to the surface. It cools quickly, within a few days or a couple weeks, forming solid rock. Very thick lava flows may take many years to become completely solid. It is made of many dark colored minerals such as pyroxene and olivine. Basalt also contains some light colored minerals such as feldspar and quartz, but the amounts are small. Basalt is an extrusive igneous rock that is very dark in color. 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 was 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 analysed 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 assigned to ferric iron that is usually not possible to assign 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 characterised as spinel with varying Ti/Fe [2] .

In this work we have analysed the basalt rock from Mount Batur volcano situated on the Island of Bali in Indonesia.We compared our results with composition of basalt rocks from some other places on the Earth.

2. Experimental Details

The samples were prepared in powder form. We scratched the powder from the surface and from the middle of the sample. Total sample weight was small, therefore the amount of specimen for the measurement was very low which prolonged recording of the Mössbauer spectra. All spectra were measured by room temperature at 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 splittings and two

magnetic sextets. These parameters and the intensity and width of the absorption peaks yield information about the amount of iron at a particular site .

3. Results and Discussion

Mössbauer spectra of volcanic rocks are given on Fig.1.The spectra consists of components related to iron-bearing phases with different content. After evaluation process we found that magnetic fraction consists of two components and non-magnetic fraction from four components. Values of internal magnetic field induction of hyperfine magnetic splitting (H 1, H 2) and quadrupole splitting (QS 1, QS 2, QS 3,QS 4) of non-magnetic components are given in Tab.1.

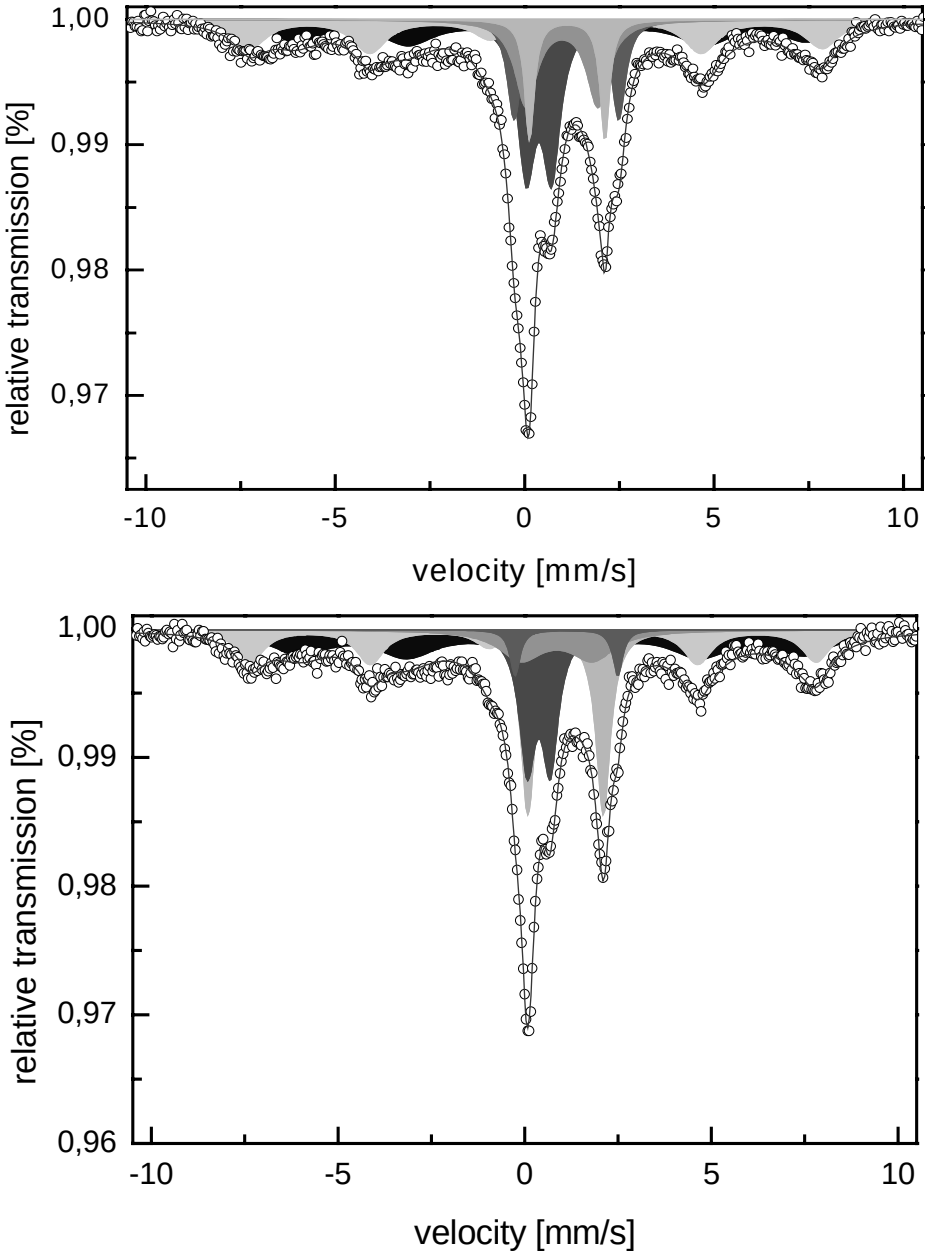

Fig.1: *Mössbauer spectra of surface (top) ,and inside of the sample (bottom)*

The doublet with quadrupole splitting around 2.75 mm/s represents Olivine, two doublets with QS in the range from 1.90 – 2.02 mm/s corresponds to Clinopyroxene. Both these components contain iron in the form of Fe^{2+}. The third doublet corresponds to Fe^{3+} component of Clinopyroxene or to small particles of iron. Magnetic component includes iron oxides of spinel-type magnetite. According to hyperfine magnetic splitting 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 magnetic and non-magnetic part, we found that their relative amount is similar in frame of 2% error in both samples. On the other hand we observed changes in non-magnetic part, if we compare the ratio of Fe^{2+}/Fe^{3+} of Clinopyroxene. For the sample from the surface is this ratio 1.14 and inside 1.59.This is an evidence of stronger oxidation processes on the surface.

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. From point of view Mössbauer spectroscopy quadrupole splitings are compared as is shown in Tab.2. Comparision from different localities show, that parameters of our samples from

Tab. 1. *Parameters of Mössbauer spectra.*

Specimen	Parameters	IS [mm/s]	QS [mm/s]	B[T]	A[%]
surface	H1s	0.29	0.02	46.9	21
	H2s	0.77	-0.13	41.9	23
	QS1s	1.10	2.75		11
	QS2s	1.12	1.99		9
	QS3s	0.38	0.67		21
	QS4s	0.99	1.90		15
inside	H1i	0.24	-0.02	47.1	19
	H2i	0.75	-0.03	42.1	29
	QS1i	1.12	2.75		4
	QS2i	1.10	2.02		21
	QS3i	0.38	0.62		17
	QS4i	0.86	1.92		10

IS-Isomer shift, QS- quadrupole splitting, B- internal magnetic field, A- area of the subspectrum, i-specimen from the inside , s- specimen from the surface of the sample

Tab. 2. *Comparison of Mössbauer parameters with other 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	this work
Hawai	1.08	2.04	4

Mount Batur correspond to basaltic volcanic rocks. We only found differences in intensity of the spectral lines and relative amount of iron phases. This is typical properties according to different localities are distinguished.

4.Conclusion

Basaltic volcanic rock samples from Mount Batur were identified by Mössbauer spectroscopy due to the complexity of the spectra and similarity of these basalts with others from different localities. Some differences were found in intensity of impurity peaks in the data. The combination of conventional geoscience methods and Mössbauer spectroscopy should allow the clear detail distinction between 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.

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