UDK 550.8

ANALYSIS OF ROCKS FROM WESTERN PART OF ANTARCTICA

J.Sitek[a], J.Dekan[a], K.Sedlačková[a], A.Gokhman[b], V.Zhukovskij[b] and **D.Tatchev[c]**

[a]Institute of Nuclear and Physical Engineering, Slovak University of Technology, Ilkovicova 3, Bratislava, Slovakia
[b] South Ukraine Pedagogical University, Odessa, Ukraine
[c]Institute oh Physical Chemistry of Bulgarian, Academy of Science, Sofia, Bulgaria

Introduction

The paleomagnetic studies of rocks may provide the fundamental information about time variation of the Earth's magnetic field [1-4]. The complex paleomagnetic research of a representative collection of Andean Intrusive Suite from the Western part of Antarctic Peninsula (near Ukrainian Antarctic base Academik Vernadsky) was carried out and the results can be found in [5]. The age of igneous complex varies between 58 and 106 million years. It is necessary to reveal the chemical composition and size distribution of the sources of magnetic field in rocks to have a correct interpretation of the data [5]. Electron microscopy study presented in [5] indicates the presence of nanosize magnetic inclusions in the investigated rocks. Information about the elemental composition, size distribution function and volume fraction of the magnetic inclusions depending on the paleomagnetic direction were also obtained.

In this work, Mössbauer spectroscopy was used for phase analysis of iron-bearing compounds with the aim to identify magnetic and non-magnetic fractions in the selected rocks of the Western part of Antarctic Peninsula from different localities. The obtained data should elucidate the directional dependence of the composition, structure, volume fraction and size of magnetic inclusions in the rocks from the Western part of Antarctic Peninsula.

Experimental

The investigated samples are polycrystalline rocks composed of several phases. These specimens are: a granodiorite (D= 350.3^o, I= -73.6 ^{o}) from the Petermann Island, a gabbro (D= 2.8^o, I= - 79.1 ^{o}) from the Cape Tuxen, a gabbro (D= 176.3^o, I= 78.0 ^{o}) from the Anagram Iceland, a gabbro (D=

10.0^o, I= -66.0^o) from the Cape Point, a granodiorite (D= 151.1^o, I= 81.8^o) from the Barchans, South Island, a granodiorite (D= 180.0^o, I= 83.7^o) from the Roca Island and a gabbro (D= 13.0^o, I= -69.0^o) from the Peterman, North-West Island. The localities of the samples collections are signed in Fig.1.

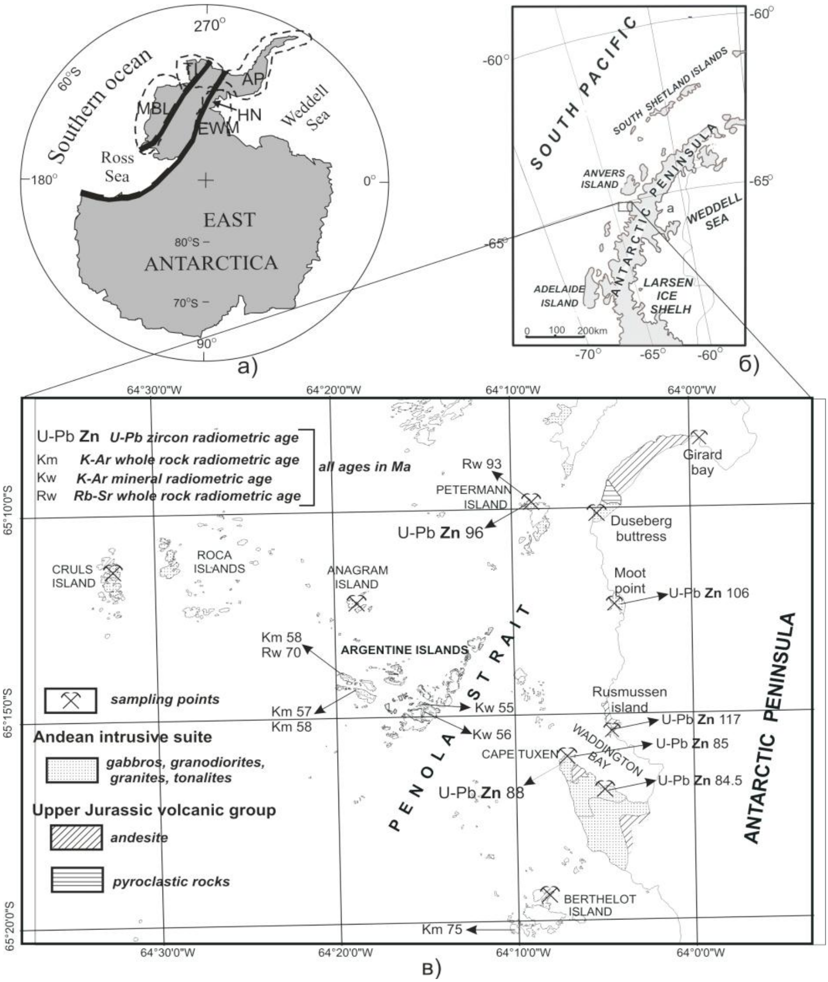

Figure 1. Localities of the samples collections.

The samples for Mössbauer experiment were studied in powder form. The Mössbauer spectra were measured at room temperature using a Wissel Mössbauer spectrometer with the Co^{57}(Rh) source in transmission geometry. Each sample was measured approximately 5 days with counts 5 million pulses per channel. The hyperfine parameters of the spectra including relative component area (A_{rel}), isomer shift (IS), quadrupole splitting (QS), as well as internal hyperfine magnetic field (B_{hf}), were evaluated by CONFIT program [6]. The accuracy in their determination is about 1% for the relative area, 0,04 mm/s for the isomer shift and quadrupole splitting and about 0.5 T for the hyperfine magnetic field. Mössbauer spectra consist of many overlapping subspectra. In order to distinguish between them correctly, a fitting model with a superposition of magnetic and non-magnetic components was applied.

In former measurements samples for XRD and SANS experiments were prepared in disks form. *Cu-K*□ monochromatic beam was used to determine the phase composition of specimens at room temperature by X-ray diffractometer DRON-3M. SANS experiment is envisaged at the YoMo beamline. Since particles with size in the nanometer range are present in the sample and it shows ferromagnetic behavior, a strong magnetic field was required to saturate the sample magnetization to the possible extent. The magnetic moments distribution was determined solely from the magnetic scattering which will eliminate the scattering from the grain boundaries and the phases with weak magnetic properties. The magnetic moments distribution as well as the ratio between magnetic and nuclear contrasts was combined with magnetic and diffraction studies to determine the composition of the nanoparticles.

Results and discussion

Samples of two classes, i.e. gabbro and granodiorite, were collected from different localities of Western part of Antarctic Peninsula. Gabbro is a dark-colored rock, which contains more than 90% of pyroxene .Gabbro may also contain small amounts of olivine, amphibole and biotite and minor amounts, typically a few percent, of iron-titanium oxides, such as magnetite and ilmenite.

Granodiorite is a phaneritic texture intrusive igneous rock similar to granite. In comprison with granit, it contains more plagioclase feldspar than orthoclase feldspar. Granodiorite has a greater than 20% quartz by volume, and between 65% to 90% of the feldspar is plagioclase. It contains minor amounts of muscovite mica, biotite and amphiboles. Minor amounts of oxide minerals, such as magnetite, ilmenite, as well as some sulfide minerals may also be present.

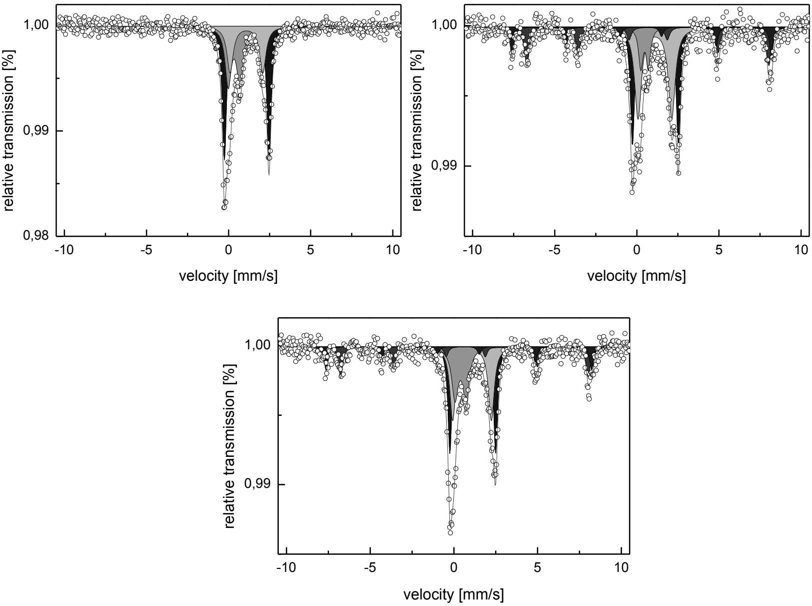

Figure 2. Mössbauer spectra of gabbro: upper left – Peterman, North West Island, upper right – Cape Tuxen, lower- Cape Point.

The Mössbauer spectra of the rocks measured at room temperature are shown in Fig. 2 and in Fig. 3, respectively. Parameters of the Mössbauer spectra of the measured samples are given in Tab. 1. The spectra of gabbros were evaluated by three doublets and two sextets. Results of gabbros analysis show that according to the values of the hyperfine magnetic field, the magnetically splitted part of the spectrum corresponds to magnetite. The non-magnetic part of the spectrum can be ascribed to pyroxene and ilmenite. Comparing the gabbro samples we found, that the samples from Cape Tuxen and Cape Point contained magnetic component and the sample from Peterman, North West Island, contained only a paramagnetic components. That means, that gabbro has different composition in the area of Antarctic Peninsula. Probably it is related to the directional changes of the Earth's magnetic field from 58 to 108 million years ago.

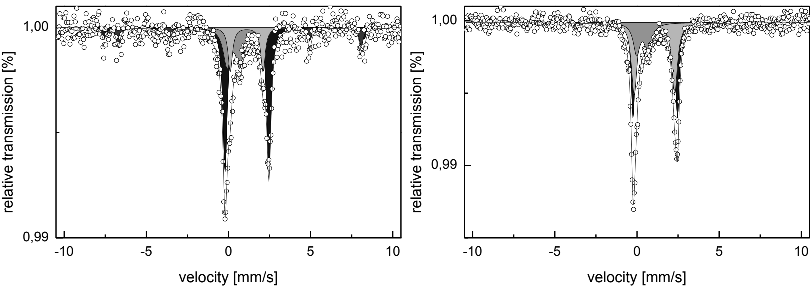

Figure 3. Mössbauer spectra of granodiorite: left- Barchans, South Island**;** right – Peterman Island.

We observed the same phenomena in the case of granodiorite. The sample from Barchans contains magnetite, pyroxene and ilmenite; and granodiorite from Peternam contains only paramagnetic components, like pyroxene and ilmenite. In all samples, the dominant phase is pyroxen. In gabbro samples, magnetite part is about 30 percents, in granodiorite approximately 20 percents. Mössbauer parameters of the internal magnetic field B are in all cases stable, what indicates, that magnetite contains a very low amount of substitution elements. On the other hand, small variance parameters of pyroxene and ilmenite indicate on the impurities or changes in the crystalline structure. We can not exclude small traces of olivine or other minerals. We also must take into account that Mössbauer parameter of the same kind of minerals differ according to locality. The data obtained from XRD and SANS experiments were found to be in agreement with the results from Mössbauer experiment. The XRD experiment indicates unambiguously on the presence of paramagnetic phases of $NaAlSi_3O_8$, $CaAl2Si_2O_8$, and Ca(Ti, Mg, Al) ($SiAl_2$). The well-known ferromagnetic phases weren't detected in XRD experiment. According to SANS, the rocks from the Cape Tuxen have the strongest ferromagnetic properties because of the presence of magnetite with a mean size of about 29 nm. Results of XRD and SANS experiments are summarized in references[1-5]

Conclusion

Phase analysis of rocks from different localities of western part of antarctic peninsula confirmed participation of magnetic component - magnetite - in gabbro as well as in granodiorite. Mössbauer study of behavior of the magnetic inclusions in rocks contribute to results from xrd, sans and electron microscopy. Finally, all these results will be used to explain relationship between of magnetic components in rocks and earth magnetic field direction as is discussed in [5].

Table 1. Parameters of Mössbauer spectra from different localities. IS- isomer shift, QS- quadrupole splitting, B-magnetic induction of internal magnetic field, A-relative amount of the components.

Locality	IS (mm/s)	QS (mm/s)	B (T)	A %
Peterman, North West Island (gabbro)	1.11	2.72		47
	1.09	1.99		24
	0.33	0.71		29
Cape Tuxen (gabbro)	1.13	2.79		26
	1.00	2.05		33
	0.47	0.46		9
	0.27	0.04	49.08	12
	0.68	0.01	45.77	20
Cape Point (gabbro)	1.13	2.73		26
	1.08	2.31		27
	0.39	0.65		20
	0.28	0.03	49.25	12
	0.67	0.08	45.97	15
Barchans, South Island (granodiorite)	1.12	2.68		45
	1.11	1.99		15
	0.30	0.77		21
	0.33	0.01	49.23	7
	0.68	0.01	45.96	12
Peterman, Island (granodiorite)	1.11	2.71		36
	1.06	2.46		43
	0.33	0.71		21

Acknowledgments

This work was financially supported by grant of Science and Technology Assistance Agency no. APVV-0516-10 and by the Ministry of Education, Science, Research and Sport of the Slovak Republic via the

projects VEGA 1/0286/12. “The access to the BER II neutron reactor has been supported by the European Commission under the 7th Framework Programme through the 'Research Infrastructure' action of the 'Capacities' Programme, ***NMI3-II Grant number 283883*****.'”**

References

1. Perrin M. , Shcherbakov V.P. : *J. Geomagn. Geoelec*. 1997, 49, № 4, 601–614.

2. Valet J.-P: *Rev. Geophys. 2003*, 41, № 1, p. 1004.

3. Poblete F., Arriagada C., Roperch P., Astudillo N., Herve F., Kraus S. Le Roux: *Earth Planet. Sci. Lett*. 2011, 302(3-4), 299–313.

4. Gokhman A, Ulbricht A., Birkenheuer U., Bergner F.: *Solid State Phenomena*, 2011, 172-174, 449-457.

5. Shcherbakova V.V., Bakhmutov V.G., Shcherbakov V.P., Zhidkov V.G., Shpyra V.V., Vynogradov Yu.K.:*Ukrainian Antarctic Journal*, 2011/2012, №10-11, 48-86.

6. Zak T., Jiraskova Y. 2006. *Surf. Interface Anal*., 38, 710-714.