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ISSN 0543-5846
METABK 41 (2) 99 (2002)
UDC - UDK 622.357:552.52:669-154=20

STUDY OF THE HYPERSTENE-AUGITIC ANDESITE FROM THE RUSKOV AREA NATURAL FORM AND REMELTING IN ATMOSPHERIC CONDITIONS

Received - Primljeno: 2001-05-15
Accepted - Prihvaćeno: 2001-10-10
Preliminary Note - Prethodno priopćenje

The structural and physico-chemical properties after remelting on a temperature over 1660 °C are researched. The chemical composition and the microscopic changes in the structure of mineral are investigated.

Key words: *hyperstene - augitic andesite, remelting, atmospheric conditions, structural and physical - chemical properties*

Studija o hiperstenom augitnom andezitu s područja Ruskova u prirodnom obliku i pretaljivanje u atmosferskim uvjetima. Istraživana su strukturna i fizičko - kemijska svojstva nakon pretaljivanja na temperaturi većoj od 1660 °C. Ispitivani su kemijski sastav i mikroskopske promjene u strukturi minerala.

Ključne riječi: *hipersteni augitni andezit, pretaljivanje, atmosferski uvjeti, strukturna i fizičko - kemijska svojstva*

INTRODUCTION

The development of the LITHO JET technology of thermic melting of rock for the purpose of sinking narrow vertical openings necessitates the identification of changes in rock properties during its conversion into melt as well as this properties after resetting. Several investigations have been carried out at the Faculty of Mining, Ecology, Management and Geotechnologies and the Faculty of Metallurgy at the Technical University in Košice in order to acquire information that would enable the planning of further research in the real rock massif.

Although the research was carried out under completely different conditions of pressure, temperature and presented vapour phase than expected in the real melting process, the achieved results are a significant contribution to the existing information on rock melting.

In this paper it is reported on the results of measurement on a sample of hyperstene - augitic andesite from Ruskov.

MATERIALS AND EXPERIMENTAL PROCEDURES

X - ray phase diffraction (XRD) analyses were carried out using a diffractometer with Ni filtered CuK_{α} radiation. Typical parameters of the analyses are shown in Table 1..

Table 1. **Typical parameters of XRD analyses**
Tablica 1. **Tipični parametri XRD analize**

System: Bragg-Bretano Anode voltage-current	30kV-20mA
Input/Output slit system	5´-10´
Counter: Geiger-Miller Treshold intensity and time constant	1000 cps, 3 s
Continous scanning rate	2°/min

The thermogravimetric and differential thermal analyses were carried out using a derivatograph with the simultaneous recording of temperature (T), weight changes (TG and DTG) and thermal effects (DTA). The experimental conditions of the TG/DTA analyses are summarized in Table 2..

Table 2. **Experimental parameters of TG/DTA analyses**
Tablica 2. **Eksperimentalni parametri TG/DTA analize**

Furnace kanthal wiring	(max. temperature 1000 °C)
Working atmosphere	Air
Crucible	No. 3
Heating rate	9.8 °C min^{-1}
Temperature range	0 - 1000 °C
CTG sensitivity	500 mg

The silicate EDS analysis was carried out using a JEOL JSM-840 electron-scanning microscope and a KEVEX DELTA+ energy dispersion microanalyzer with MIRROR QUANTEX+ software. This analysis provides a very ac-

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curate picture of the chemical composition of the observed Biotitic - quartzitic gneisses sample. The experimental conditions of the EDS analyses are summariued in Table 3.. Optical analyses were carried out using a JENAPOL polarisation microscope.

Table 3. **Experimental parameters of EDS analyses**
Tablica 3. **Eksperimentalni parametri EDS analize**

File Version: 1	Beam Current: 1210.0 picoAmps
Background Method: Auto	Working Distance: 11.0 mm
Decon Method: Gaussian	Tilt Angle: 0.0 Degrees
Decon ChiSquared: 2.4	TakeOff Angle: 56.5 Degrees
Microscope: SEM	Solid Angle*BeamCurrent: 3.4

The WDS analyses (with an accuracy of measurement of 0.01 weight percentage) was used to analyze the remolten sample using a JEOL JXA - 733 SUPERPROBE electron wave - dispersion micro - analyzer with 4 spectrometers that were supplied with TAP, PET and PIF diffraction crystals.

The microanalyzer was controlled by a KEVEX SEMAME system using a SAMx software and an IBM - PC.

GEOLOGICAL CONDITIONS
PETROGRAPHY CHARACTERISTICS

Rock sample, which was subject of investigation within the frame of the LITHO - JET project, had been taken from the Slanske vrchy mountain, east part of the Slovakia. From geomorphologic classification point of view the Slanske vrchy mountain belongs to the Matro - Slanska mountain range of the West Carpathian subprovince. From regional and geological classification of the West Carpathian mountain chain the region of the Slanske vrchy belongs to the block of neovolcanites situated in east direction from Košice city. Slanske vrchy mountain chain is composed of morphologically remarkable volcanic massif. Substantial part of mountain chain is composed from sediments and neogene volcanites with stratigraphic span from Carpathian to Panonian. In addition, quaternary covered sediments are also present.

The analyzed rock was taken from stone-pit in southeast direction from Ruskov village. The stone - pit is situated in the bottom of volcanic massif of which the top altitude Hradisko is 708 m above sea level. From the geological point of view the volcanic massif constitutes individual andesite stratovolcano of south part of the Slanske Vrchy mountains. Rocks, of which the stratovolcano is formed, are membered into lower and upper structural stage and they are partly separated by sediments. Lower structure stage constitutes basic part of stratovolcano mostly consisting of lava flows of andensites, from wh-ere the analysed sample was taken. Lava flows form completions with the variable thickness, which are separated by zones of the lava breccias. The andensites are perturbed by the flaw systems, they have irre-gular polygonal disinte-grationand some parts of flows also notable platy-sheet parting. Volcanic activity, during which the lava flows have originated, was determined radiometric method from the andesite flows as to belong to the bottom Sarmatian. Upper structure stage is also formed of andesite lava flows, which are situated in the andesite hanging of the lower structural stage and they are younger belonging to the upper Sarmatian - Panon era.

Figure 1. **Hyperstene-augitic andesite from Ruskov, Polarides X, magnification 59 x**
Slika 1. **Hipersteno-augitni andezit iz Ruskova, polaridi X, uvećanje 59 x**

From the macroscopic point of view the sample consists of gray to grayish - brown, compact fine and medium porphyritic rock. However, local areas of the sample are dark - gray and porous.

From the microscopic point of view the sample posses porphyritic structure with pilotaxitic structure of ground matrix, which is formed of fine lathes of plagioclases and grains of pyroxenes (Figure 1.). Phenocrysts are mostly formed of plagioclases (An_{45-85}), to less extend by the pyroxenes – hyperstene, augite, occasionally amfibole. The glomeroporphyritic crowds of phenocrysts can be observed locally. Magnetite is present secondary mineral.

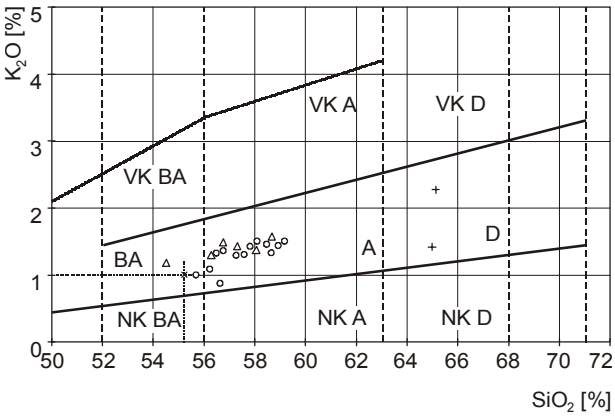

Figure 2. **Classification diagram (Peccerillo and Taylor)**
Slika 2. **Klasifikacijski dijagram (Peccerillo i Taylor)**

According to the microscopic analysis the sample is volcanic rock, hyperstene - augitic andesite. From the petrochemical point of view it is rock type (Table 4.) which can be, based on the Peccerillo and Taylor (Figure 2.), Le Base and Gill (Figure 3.) classification diagrams assigned as basaltic andesite medium potassic type [1].

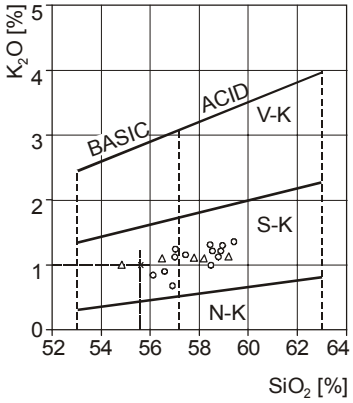

Figure 3. **Classification diagram (Gill)**
Slika 3. **Klasifikacijski dijagram (Gill)**

CHEMICAL ANALYSIS

The results of the chemical composition analyses are listed in Table 4.. The sample contains a high content of SiO_2, Al_2O_3, CaO and FeO.

Table 4. **Results of the EDS analyses**
Tablica 4. **Rezultati EDS analize**

Elt	Line	Weight %	Cmpt	Cmpt WT%	Decon Regions	Atomic %
O	-	44.74	-	-	-	61.86
Na	Ka	2.15	Na_2O	2.89	0.830 - 1.270	2.07
Mg	Ka	1.27	MgO	2.11	1.050 - 1.490	1.16
Al	Ka	11.00	Al_2O_3	20.79	1.280 - 1.720	9.02
Si	Ka	25.87	SiO_2	55.34	1.530 - 1.980	20.37
K	Ka	0.97	K_2O	1.16	3.060 - 3.590	0.55
Ca	Ka	6.67	CaO	9.33	3.430 - 3.970	3.68
Ti	Ka	0.20	TiO_2	0.33	4.230 - 4.810	0.09
Cr	Ka	0.22	Cr_2O_3	0.32	5.120 - 5.730	0.09
Mn	Ka	0.00	MnO	0.00	0.000 - 0.000	0.00
Fe	Ka	2.82	FeO	3.63	6.080 - 6.740	1.12
Total	-	95.91	-	-	-	-

XRD ANALYSES

The diffraction pattern is shown in Figure 4., which confirms the very high content of SiO_2. Owing to the high background the sample is though to contain a considerable share of phases in amorphous state [1].

DTA, TG ANALYSES

The melting of the specimens occurs at 1660 °C. The differential thermal and thermogravimetric analyses were carried out using a derivatograph with simultaneous recording of temperature, weight changes and thermal effects [2].

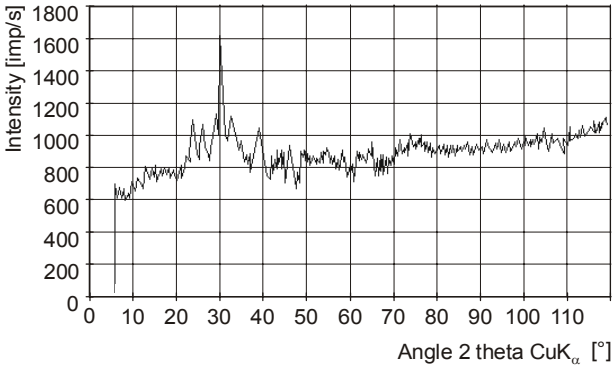

Figure 4. **Diffraction pattern of hyperstene-augitic andesite**
Slika 4. **Rezultat difrakcije hipersteno-augitnog andezita**

No weight change was observed in the temperature range 25 - 1000 °C. In addition, no exo or endo effect was observed. Based on these facts it can be stated that no phase or weight changes take place during heating up to 1000 °C - Figure 5. and 6..

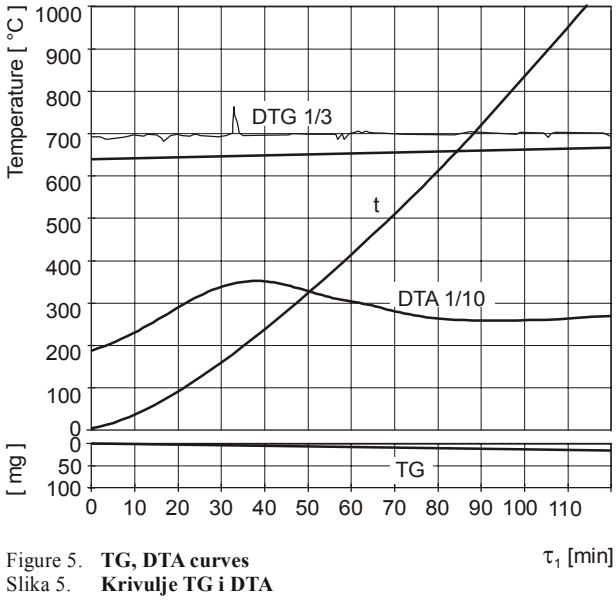

Figure 5. **TG, DTA curves**
Slika 5. **Krivulje TG i DTA**

PETROGRAPHY CHARACTERISTICS OF THE REMOLTEN

Macrodescription:

Black compact glassy rock with local porous vesicular texture. Diameters of the spherical and oval cavities are in the range up to 0.6 cm.

Microdescription:

Gray to gray-black rock with hyaline structure and weak curly slips that are consequence of fluidal flow of glassy matter [3].

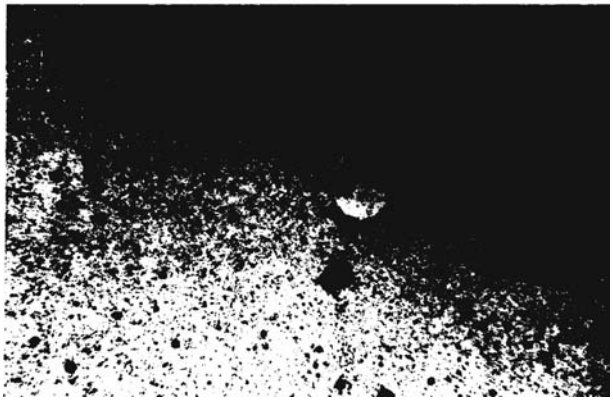

Figure 6. **The remolten hyperstene-augitic andesite (1660 °C), Polarides X, magnification 59 x**
Slika 6. **Pretaljeni hipersteni augitni andezit (1660 °C), Polaridi X, uvećano 59 x**

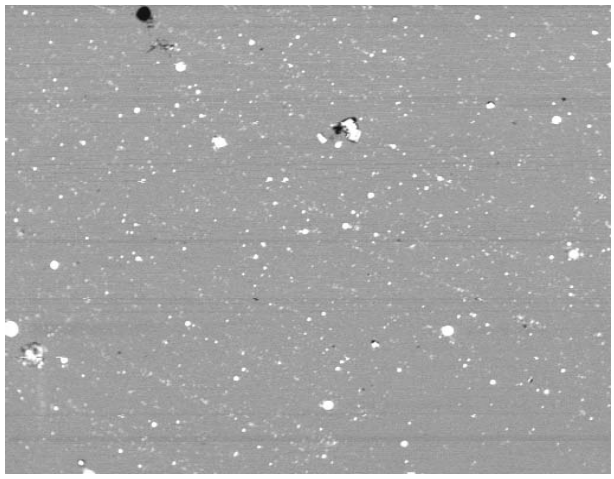

Figure 7. **Remolten hyperstene-augitic andesite fromRuskov, BEI picture, magnification 86x**
Slika 7. **Pretaljeni hipersteni augitni andezit iz Ruskova, slika BEI , uvećano 86 x**

Chemical Analysis of the Remolten Biotitic-Quartzitic Gneisses

The melt of the Ruskov - sample (Figure 7.), which obtained after melting at 1660 °C, was analysed after re-setting using EDS and WGS analyses.

Wds Analysis of the Remolten Sample

The results of the WDS analysis are listed in Table 5..

Xrd Analysis of the Remolten Sample

The diffraction specter in Figure 8. shows that almost the entire sample is in amorphous state. Based on the XRD

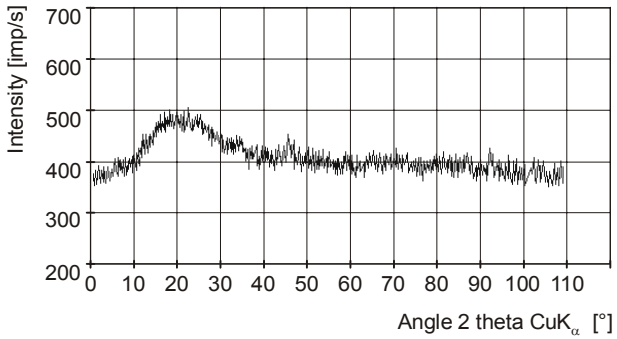

Figure 8. **Diffraction specter of biotitic-quartzitic**
Slika 8. **Spektar difrakcije na biotitno-kvarcitnog gneisa**

Table 5. **Results of the WDS analyses of the sample after melting**
Tablica 5. **Rezultati WDS analize uzorka nakon taljenja**

Elt	W %	interval (95 %)	A %	Ix/Istd	Kratio	Z. A. F. coefc			Ox %	Cat #
O	45.83	-	61.80	-	-	-	-	-	0.00	0.00
F	0.00	[0.00 - 6.44]	0.01	0.0000	0.0000	1.0146	4.4383	1.0043	0.01	0.00
Na	2.54	[2.31 - 2.78]	2.38	0.2794	0.0132	1.0395	1.8526	1.0001	3.43	0.23
Mg	1.75	[1.63 - 1.88]	1.56	0.0251	0.0116	1.0216	1.4943	0.9918	2.91	0.15
Al	10.40	[10.15 - 10.65]	8.32	0.1809	0.0767	1.0594	1.2921	0.9896	19.65	0.81
Si	26.97	[26.57 - 27.37]	20.72	0.5146	0.2054	1.0353	1.2670	0.9992	57.70	2.01
P	0.01	[0.00 - 0.16]	0.01	0.0003	0.0000	1.0763	1.3923	1.0071	0.01	0.00
Cl	0.04	[0.00 - 0.08]	0.02	0.0005	0.0003	1.1067	1.1606	0.9958	0.04	0.00
K	1.21	[1.03 - 1.40]	0.67	0.0953	0.0104	1.1103	1.0658	0.9900	1.46	0.07
Ca	6.73	[6.38 - 7.08]	3.62	0.1890	0.0592	1.0899	1.0446	0.9987	9.42	0.35
Ti	0.60	[0.49 - 0.72]	0.27	0.0090	0.0049	1.2033	1.0284	0.9984	1.01	0.03
Cr	0.00	[0.00 - 1.07]	0.00	0.0000	0.0000	1.2176	1.0111	1.0146	0.00	0.00
Mn	0.11	[0.00 - 0.27]	0.04	0.0034	0.0009	1.2460	1.0060	1.0019	0.14	0.00
Fe	1.52	[1.21 - 1.83]	0.59	0.0191	0.0123	1.2292	1.0023	1.0000	1.95	0.06
Sum	97.72	-	100.00	-	-	-	-	-	97.72	3.71

analysis it can be stated that the sample mainly consists of amorphous matter. Some diffraction of the micro-crystallites which remained in the solid state during melting are observed in the diffraction range 20 - 35 2 Θ.

CONCLUSION

It follows from the petrographic point of view that hyperstenic-augite andesite had porfyric structure with pilotaxic structure of ground matrix which was formed by the fine lathes of plagioclase and pyroxene grains. Phenocrysts were formed mostly from plagioclase, to less extend from pyroxene-hyperstene and augite. The presence of the mentioned minerals was proved also by the EDS analysis using energy-dispersive microanalyzer with MIROR QUANTEX+ software. After melting at 1600 °C the sample changed to the black compact glassy matter with local porous vesicular texture. Hyaline structure with the tangs of fluidal flow of glassy matter was identified during microscopic observations.

Based on the classic chemical analysis it was determined that basic constituents of hyperstenic-augite andesite are SiO_2, Al_2O_3 and CaO. Amount of the rest constituents is below 5 wt. %. The results of this analysis were farther improved by the EDS analysis. Primary, sample was melted at 1600 °C and subsequently analyzed by the classic chemical and WDS analysis. WDS analysis extended the number of the analyzed elements, namely P and Cl and their oxides [4]. The results showed that the amount of analyzed constituents did not change significantly during melting.

XRD analysis of primary hyperstenic - augite andensite confirmed high amount of SiO_2 together with the minor amounts of Al_2O_3 and MgO. From the mineralogical analysis it follows that the augite, pyroxene and plagioclase are present. X-ray diffraction analysis of the remolten hyperstenic - augite andesite revealed that major part of the sample is in the amorphous state.

DTA analysis and thermogravimetric measurements indicate, that in the temperature range 25 - 1000 °C no weight changes or phase transformations take place.

The measurement of viscosity at 1600 °C could not be realized because of very high viscosity even at such high temperature.

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