CHEMICAL COMPOSITION, TRACE ELEMENTS, AND VOLATILE COMPONENTS OF MELTS: EVIDENCE FROM INCLUSIONS IN THE MINERALS OF NEOVOLCANITES FROM THE CENTRAL AND EASTERN SLOVAKIA

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Abstract: The primary high density fluid inclusions of the magmatic water (0.59-0.94 g/cm^3, P=3.3-8.4 kb at 700-900^{0}C) are found in the volcanic rocks. The melt inclusions containing glass and high density aqueous solution (0.79-1.08 g/cm^3) in phenocrysts from andesites. The fluid pressure was 5.6-15 kbar at 800^{0}C. The chemical composition of melts including the volatiles and rare elements content is studied as well.

Key words: melt inclusions, trace elements, volatile, Slovakia

Introduction

It is conditioned now, that initiation of the ore-forming system activity in the volcanic structures with epithermal ore mineralization relates to the subvolcanic intrusions. These intrusions supply the system with heat and induce the fluid convection. However, the important problem of the metal and volatile (H_2O, CO_2, Cl, S, and F) sources for hydrothermal solutions is still poorly known. The other problem concerning the influence of magmatic evolution style on the type of ore mineralization is unclear as well. In this report some new data concerning the magmatic melt chemical composition, volatile and rare element content in it are discussed. The data relate to the melt and fluid inclusions in phenocrysts from andesites and rhyolites at the Štiavnica caldera (Central Slovakia) and from rhyodacites at the Maly Kamenec (Eastern Slovakia). The geological structure and magmatic activity of the region are carefully studied and published by the Slovak geologists (Konecny et al., 1995; Lexa et al., 1999).

Results

More than 100 unusual primary melt inclusions from 2 to 62 microns I diameter are found in some plagioclase phenocrysts from the andesite at the Štiavnica caldera. The inclusions concentrate in the peripheral zone of the phenocrysts and are composed with silicate glass and one or several (up to 7) translucent fluid bubbles. The fluid phase consists of chloride aqueous solution with salinity corresponding to 4.5 wt % of the NaCl equiv. as a whole and density 0.79-1.08 g/cm^3. Such high fluid density undoubtedly corresponds to high fluid pressure, that could reach 5.6-15 kb at 800^0C. Calculations of the volatile content in magmas (Table 1, nos.3 and 4) show high content of as water (7.0-11.9 wt %), as Cl (0.32-0.46 wt %). Interesting, that the andesitic groundmass composition is quite similar to the total composition of rhyolite, and the melt composition of inclusions in plagioclases from the andesite show trend of Na content decreasing toward the rhyolite composition in the system of normative quartz-K-feldspar-albite. The same trend show melt inclusions from rhyolites. This allows to propose the single magma source chamber for the andesite and rhyolites of the Štiavnica caldera.

Some primary fluid inclusions (9-120 microns in diameter) are found along with silicate melt inclusions (Table 1, nos.6 and 7) in the quartz and sanidine phenocrysts from rhyolites at the Štiavnica caldera. They concentrate in peripheral zone of phenocrysts and somewhere associate with melt inclusions. No secondary fluid inclusions were observed, so there was no hydrothermal processes overlapped these rhyolites. 83 fluid inclusions were studied. Their salinity appears to be 1.7-3.9 wt % NaCl eq., they homogenized into the liquid phase at $125\text{-}320^0$C, that corresponds to high fluid density (0.70-0.96 g/cm^3) and high pressure. In the fluid phase coexisting with silicate melt (3.3-8.7 kb at $700\text{-}850^0$C). Such overpressure values cannot be understand without the fluid flow intervention into the magma from the deep level magmatic chamber. This flow was ascended from the great depth and influenced the magma crystallization process. Some higher content of Cr, Zr, Sr can be the prints of deep seated basic magma chamber.

As many silicate melt (Table 1, nos. 9 and 10) as two high density magmatic water fluid (0.59-0.83 g/cm^3) inclusions were found also in the plagioclase phenocrysts from the rhyodacite at the southern part of the Eastern Slovakia (around the Maly Kamenec settlement). Secondary fluid inclusions are absent at all. The solution salinity is 1.7-8.3 wt % of the NaCl equiv. The calculated fluid pressure at 900^0C is rather high (3.3-8.4 kbar).

The content of 18 trace elements in the silicate melt inclusions of the three studied occurrences (Table 2) was measured with ion microprobe analysis. The significant difference between the melt composition of the two plagioclase phenocrysts probably relates to the fluid-magma interactions in andesitic magmas. The melt in the second column is poor with almost all rare elements, but enriched with Sr and Cl in compare with the first sample. The introduction of the fluid flow in the subliquidus andesitic magmas could result in redistribution of rare elements, especially of REE from silicate melt to fluid phase. Local flows could cause the heterogeneous melt composition.

So, the new obtained data confirm the proposition, that ore-related magmas in the Štiavnica caldera evolved under influence of the fluid flow intervention from the deep level magmatic chamber.

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Table 1. Chemical composition (wt. %) of samples, matrix glasses, and glasses of melt inclusions in minerals from of neovolcanites Central and Eastern Slovakia

Table 2. Chemical composition of petrogenic, volatile components, and trace elements in glass from melt inclusions in minerals of neovolcanites Central and Eastern Slovakia

Table 1.

Component	Stiavnica caldera							Maly Kamenec		
	Andesite (sample 4-90)				Rhyolite (sample 6-90)			Rhyodacite (sample 88-90)		
	1	2	3	4	5	6	7	8	9	10
SiO_2	62.23	73.32	68.94	65.02	72.20	75.81	73.58	70.40	72.81	73.04
TiO_2	0.56	0.11	0.09	0.08	0.24	0.05	0.05	0.30	0.07	0.05
Al_2O_3	16.91	12.66	13.17	12.50	13.09	11.33	11.47	14.62	15.77	12.82
FeO	5.14	0.83	0.90	0.85	2.63	1.00	0.63	3.14	1.10	0.84
MnO	0.09	0.05	0.04	0.04	0.02	0.07	0.04	0.00	0.04	0.04
MgO	2.15	0.07	0.13	0.12	0.22	0.09	0.06	0.29	0.06	0.04
CaO	4.72	0.56	1.40	1.38	0.38	0.62	0.82	2.90	1.28	0.89
Na_2O	3.10	2.04	2.46	2.45	1.26	2.23	3.96	3.78	4.55	4.36
K_2O	2.93	6.45	5.58	5.22	8.78	6.28	4.49	3.23	3.73	5.24
Cl	-	0.14	0.32	0.46	-	0.27	0.17	-	0.11	0.21
H_2O	2.05	-	6.97	11.88	0.90	-	3.74	0.94	-	0.38
Total	99.88	95.23	100.00	100.00	99.72	97.75	99.01	99.62	99.52	97.91

Note: 1, 5, 8 - volcanic rocks, 2 - matrix glass of andesite, 3, 4, 6, 7, 9, 10 - glass of melt inclusions in plagioclase (3, 4, 9), sanidine (6) and quartz (7, 10).

Table 2.

Compo-nent	4-90*	4-90	6-90	88-90	Compo-nent	4-90	4-90	6-90	88-90
		wt %					ppm		
SiO_2	73.55	74.48	71.56	70.63	Li	2.88	30.8	40.1	60.5
TiO_2	0.10	0.13	0.04	0.11	Be	2.28	3.70	1.64	2.69
Al_2O_3	11.77	12.23	11.85	14.43	B	82.7	38.6	34.7	45.5
FeO	1.27	1.31	0.63	0.87	Zr	90.2	23.2	54.0	94.7
MnO	0.05	0.07	0.08	0.06	Y	11.6	2.20	11.9	45.9
MgO	0.18	0.20	0.05	0.04	Nb	27.2	8.10	12.5	11.9
CaO	0.98	0.73	1.06	0.92	Th	18.7	2.50	13.4	13.2
Na_2O	3.66	2.09	4.66	5.52	Sr	344	903	61.3	36.6
K_2O	6.35	6.06	6.41	6.93	Ba	637	143	470	913
Cl	0.24	0.36	0.19	0.20	Cr	1.40	-	0.56	1.12
H_2O	0.29	0.26	3.74	0.38	La	48.4	16.3	29.7	30.3
Total	98.44	97.92	100.27	100.09	Ce	71.1	21.4	52.7	64.9
Host	Pl	Pl	Q	Q	Nd	21.9	4.30	12.8	24.3
Note: * - number of sample,					Sm	2.18	0.39	2.31	5.37
Pl - plagioclase, Q - quartz					Eu	1.13	1.24	0.15	1.14
					Dy	1.58	0.40	1.57	5.19
					Er	1.10	0.44	1.07	3.25
					Yb	0.95	0.26	1.19	4.07