Geochemistry of Li-Rich Aplite-Pegmatites Enclosed in Bituminous Limestones (Sangilen Area, South Siberia)

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ABSTRACT

Geochemical peculiarities of Li-rich granitoids were investigated in some pegmatite deposits of Sangilen area (South Siberia). Dyke swarms of aplite-pegmatites occur near fracture zones in bituminous limestones. Carbon was assimilated by intruded granitic melts. Spodumene-rich granitoids represent unusual evolutionary sequence, resulted in their very high average Li content. This is probably due to superliquidus differentiation of granitic melts at reduced C-O-H fluid conditions.

Key-words: *pegmatite, lithium, structure, differentiation, fluid conditions.*

INTRODUCTION

Among many Li-rich pegmatite occurrences worldwide some are represented by the veins with a homogeneous internal structure, i.e. without any distinct zonation. They are composed by the rocks of rather simple mineral content (quartz, feldspars and Li-aluminosilicate – spodumene or petalite). But they usually display a textural inhomogeneity characterized by a spatial alternation of aplitic and pegmatitic components. In most of them lithium was selectively partitioned into the pegmatitic differentiates (Charoy et al., 2001). Much more rarely some part of aplites also carry lithium aluminosilicates (Zagorsky & Kuznetsova, 1990). In the Sangilen rare-metal pegmatite belt Li-rich aplites are widespread. The main geochemical peculiarities of these rocks are shown in this paper.

DISCUSSION

In the Sangilen highland numerous spodumene-bearing aplite-pegmatite dykes make up dense swarms of several bodies (subvertical, elongated, from 2 to 25 m thick). They display typical injection features and occur in linear fracture zones in the vicinity of granitic plutons of Early Paleozoic age. Most of them are intruded into a thick sequence of Proterozoic bituminous limestones.

Location of pegmatite deposits next to abyssal fracture zones and formation in unstable tectonic conditions prevented initial melts from prolonged differentiation. Thus, all dykes have weekly zoned internal structure with predominant fine-grained spodumene-bearing aplitic rocks, unevenly associated (in the larger dykes) with coarse-grained also spodumene-bearing pegmatitic components. The assemblage of rock-forming minerals includes quartz, K-feldspar, plagioclase and spodumene in variable proportions. Remarkably, that spodumene - the single Li-aluminosilicate phase - occurs as the main rock-forming mineral jointly in associated aplites and pegmatites. Its average concentration in aplites sometimes reaches higher levels, than in pegmatites, saturated with large separations of quartz and K-feldspar.

Aplites are characterized by considerable primary heterogeneity in the distribution of rock-forming minerals (including spodumene) and it is astonishing for the rocks with fine-grained texture owing to a rapid crystallization. Comparison of aplite varieties from many dykes made it possible to recognize regularity in

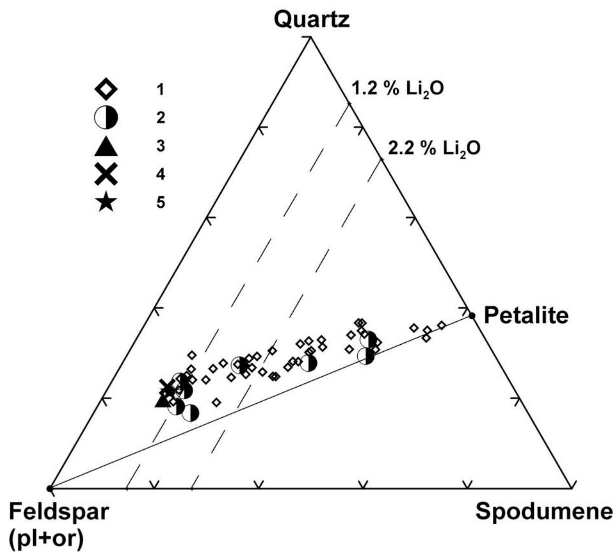

FIGURE 1. A plot of the composition of spodumene granitoids from several Li-deposites of Tuva, recalculated to 100 wt.% - combined alkaly feldspars, quartz and spodumene.
1 spodumene-rich aplites from different dykes (obtained by selective sampling); 2 average bulk composition of some Li-enriched dykes (obtained by channel-sampling across aplite-pegmatite dykes); 3 spodumene-bearing granite of the Alakhinsky intrusion, South Siberia; 4 average bulk composition of some worlds known Li-enriched pegmatite veins with homogeneous internal structure; 3,4 - from (Beskin et al., 1999); 5 macusanite – from (London et al, 1989).

the modifying of their bulk composition and texture. In each dyke swarm they display the same and rather wide evolutionary sequence of compositions (fig.1) directed towards enrichment of rocks in spodumene instead of feldspars (Kuznetsova, 2004). This sequence is totally different from "albite" evolutionary trend typical for development of H_2O-F-B-saturated haplogranite systems. Differentiation processes in larger lithium deposits usually occur at a larger scale. As it was ascertained in some large deposits like Tastyg, the dykes formed by aplite varieties with rather different average lithium content are marked by some morphological peculiarities and separate location.

Geochemical investigation shows that lithium-rich aplites were formed from water-undersaturated melts with low activity of F, B, P and high activity of CO_2, CH_4, N_2 (Kuznetsova, 2004). Our assumption concerning H_2O-undersaturation of initial melts corresponds with some experimental researches (London et al., 1989). As it is known (Ebady &

Johannes, 1991), "the activity and the amount of water in the melt may be controlled by the composition of the coexisting vapor phase, …water may be deluted by other gas components (e.g., CO_2, CH_4, N_2)". Reduced fluidal regime in Li-bearing melts was buffered by the carbon captured from the host rocks. Low activity of H_2O, F, B resulted (i) in reduced amount of pegmatitic facies, (ii) in very limited scale of hydrothermal metasomatic processes in aplites and (iii) in almost total lack of chemical interaction of dykes with carbonaceous host rocks. Recrystallization and leaching out the carbon components – the only signs of alteration in the adjacent limestones. Variations of Li contents in aplites never exhibit any control by fluid components. These facts suggest that enrichment of aplites in Li is owning to differentiation of initial melts. However some geochemical features of these rocks seems discordant with this conclusion.

TABLE 1. Composition of spodumene granitoids

№	1	2	3(3)	4(3)
SiO_2, wt.%	72.25	74.10	73.53	76.24
TiO_2	0.01	0.02	0.01	0.02
Al_2O_3	16.20	15.80	15.75	16.82
Fe_2O_3	0.30	0.08	0.09	0.19
FeO	0.71	0.65	0.87	1.29
MnO	0.04	0.06	0.05	0.09
MgO	0.04	0.03	0.03	0.05
CaO	0.25	0.20	0.49	0.21
K_2O	2.87	1.30	3.02	0.07
Na_2O	5.02	6.30	4.23	0.33
P_2O_5	0.20	0.17	0.01	<0.02
Li_2O	0.75	0.82	1.26	4.28
H_2O	0.60	0.60	0.15	0.14
CO_2	n.d.	n.d.	0.31	0.10
F	0.06	0.09	0.04	0.05
Total	99.30	100.22	99.65	99.89
B, ppm	n.d.	n.d.	9	11
Be	140	180	20	23
Sn	n.d.	400	300	>100
Ba	n.d.	n.d.	65	35
Sr	n.d.	n.d.	70	39
A/CNK	1.36	1.29	1.42	16.5
A/NKL	1.16	1.08	1.09	1.11

Note. 1.Spodumene-bearing granite of the Alakhinsky intrusive stock, South Siberia (Beskin et al., 1999). 2.Average bulk composition of some worlds known Li-enriched pegmatite veins (Beskin et al., 1999). 3-4 Spodumene-rich granitoids of Tuva: 3 quartz-spodumene-two-feldspars variety with granitic texture; 4 quartz-spodumene variety with microporphiritic fluidal texture. In brackets: number of samples; n.d.: not determined. A/CNK= mole $Al_2O_3/(CaO+Na_2O+K_2O)$; A/NKL= mole $Al_2O_3/(Na_2O+K_2O+Li_2O)$.

Bulk chemical compositions of aplites which was obtained not only by selective sampling, bat also by channel-sampling across some spodumene-bearing aplite-pegmatite dykes, demonstrate that their average Li_2O content varies from 1.2 up to 4.3 wt.% (Table 1). Thus, in some aplite varieties its level is much higher than 2.2 wt.% - the upper limit of Li_2O that can accumulate in a water-saturated haplogranite melt (Stewart, 1978). In addition, silica and lithium contents of the rocks increase simultaneously, but Si/Li ratio in aplites never exceeds Si/Li ratio of petalite (fig.1). In some larger lithium deposits of Sangilen area (Tastyg, Shuk-Byul, Kara-Adyr) evolutionary sequence of aplites is completed by almost bimineral quartz-spodumene variety with microporphyritic fluidal texture. Its bulk chemical composition approaches the composition of petalite (Kuznetsova, 2004) (Table 1). But texture and location features of this aplite variety make impossible its identification with products of isochemical replacement of petalite (referred as "squi"). Besides, petalite or its relics are absent in spodumene-bearing dykes in Tuva.

CONCLUSION

Petrologic peculiarities of spodumene-rich granitoids in the Sangilen area cannot be explained from a generally accepted viewpoint. Some investigators (Slobodskoy, 1979; Letnikov, 2001; Bezmen et al., 2005) demonstrated that fluidal regime of granitic melts on the earlier evolutionary stage may display more reduced conditions than on the later stage and thus promote their superliquidus differentiation. Possibly this model can be applied for explanation of the origin of Li-rich aplites in Tuva. Reduced fluidal regime of their parental melts was buffered by carbon captured from the host rocks. Extreme enrichment in Li may proceed in water-undersaturated melts due to superliquidus differentiation at reduced C-O-H fluid conditions. Melts delamination may be redoubled by convection owning to their rapid intrusion.

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