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TRACE ELEMENTS IN QUARTZ FROM LI-ENRICHED PEGMATITE

by

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Introduction

Concentration of trace elements in rock-forming minerals is often used for evaluation of fractionation trends of magmatic rocks. However, in case of granitoids, the most common minerals like feldspar or mica are often altered during post-magmatic fluid-related processes. Quartz is more resistant and its magmatic trace-element signature is usually preserved.

Improvement of microanalytical methods in last two decades stimulated numerous studies focused on trace element composition of granitic (e.g. Jacamon and Larsen, 2009; Breiter and Müller, 2009; Deans, 2010; Breiter et al., 2012, 2013) and pegmatitic (Larsen et al., 2000, 2004; Götze et al., 2005; Müller et al., 2008) quartz. Nevertheless, detailed studies about evolution of quartz in complex pegmatites are still scarce (Beurlen et al., 2011, Breiter et al. in print).

Aims of this contribution are:

(i) to describe evolution of the trace-element pattern in quartz during crystallization of fractionated Li-enriched pegmatite body,

(ii) to evaluate the influence of mineral assemblages to distribution of trace elements in quartz,

(iii) to compare contents of trace elements in quartz from pegmatites and granites.

Analytical conditions

Trace element (Al, B, Ba, Be, Cr, Fe, Ge, Li, Mn, P, Rb, Sn Sr, and Ti) contents in quartz were analyzed using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) at the Institute of Geology, Academy of Sciences of the Czech Republic using a Thermo-Finnigan Element 2 sector field mass spectrometer coupled with the 213-nm NdYAG laser (New Wave Research UP-213). The isotopes ^{29}Si and ^{30}Si were used as the internal standards based on presumption that the analyzed quartz contains 99.95 wt% SiO_2. The data were calibrated against the external standard of synthetic silicate glass NIST SRM 612. For more details see Breiter et al. (in print). Homogeneity of quartz grains was controlled prior the analyses with the cathodo-luminescence.

Results and discussion

We studied samples of quartz from all major textural zones from two complex pegmatites from western Moravia, Bohemian Massif, Czech Republic (Cháb et al., 2009): the Rožná lepidolite pegmatite (Novák and Cempírek, 2010), and the beryl-columbite Věžná I pegmatite (Dosbaba and Novák, 2012). Both selected pegmatites are of peraluminous LCT-type. For description of individual samples and contents of the genetically most important trace elements see Table 1.

Locality	Sample no.		Li	Ge	Al	Ti
Rožná	RO-1	coarse-grained border unit with biotite	4.9	1.3	109	22
	RO-2	graphic unit with muscovite	6.6	2.6	153	16
	RO-3	granitic unit with schorl	7.5	3.4	147	11
	RO-4	coarse-grained albite subunit with schorl to Fe-rich elbaite	32	4.2	320	8.9
	RO-5	albite subunit with lepidolite and Fe-rich elbaite	4.2	9.6	121	1.5
	RO-6	quartz core	23	10	235	1.4
Věžná	Věž-1	granitic unit with biotite	14	0.78	72	29
	Věž-2	granitic unit-to-coarse-grained unit with biotite	14	0.73	114	25
	Věž-3	graphic unit	20	1.2	140	39
	Věž-5	blocky unit	24	2.6	211	43

Table 1

Description of samples and selected trace element concentrations (means in ppm) in quartz. For complete analytical data see Breiter et al. (2012a) and Breiter et al. (in print).

Among all analyzed trace elements, contents of Al are the highest and systematically increase from the margin to the core zones in Rožná and Věžná pegmatites (109 to 235 ppm and 72 to 211 ppm, respectively). Contents of the second most abundant element, Ti, decrease systematically from margin to core in Rožná, but scattered in Věžná. Because the increasing Al/Ti ratio in quartz is generally accepted as reliable indicator of granitic magma fractionation (Jacamon and Larsen, 2009, Breiter et al., 2012b), this ratio is used for demonstration of evolution of other trace elements in Figs. 1 and 2.

Germanium has similar crystallochemical parameters like Si and is, in very small amount, present in all silicate minerals. Contents of Ge in quartz well correlate with Al/Ti ratios (Fig.1a) and it is concentrated predominantly in the latest stages of the Rožná pegmatite fractionation – in the albite-lepidolite zone and in the quartz core. This is consistent with theoretically predicted behavior of disseminated incompatible trace element. Contents of Ge in Věžná are lower, but the trend is similar.

Distribution of Li strongly differs from those of Ge (Fig. 1b), although the tendency to increase in the late phases of crystallization is also well visible. Lithium, unlike Ge, is able to form its own minerals like lepidolite.

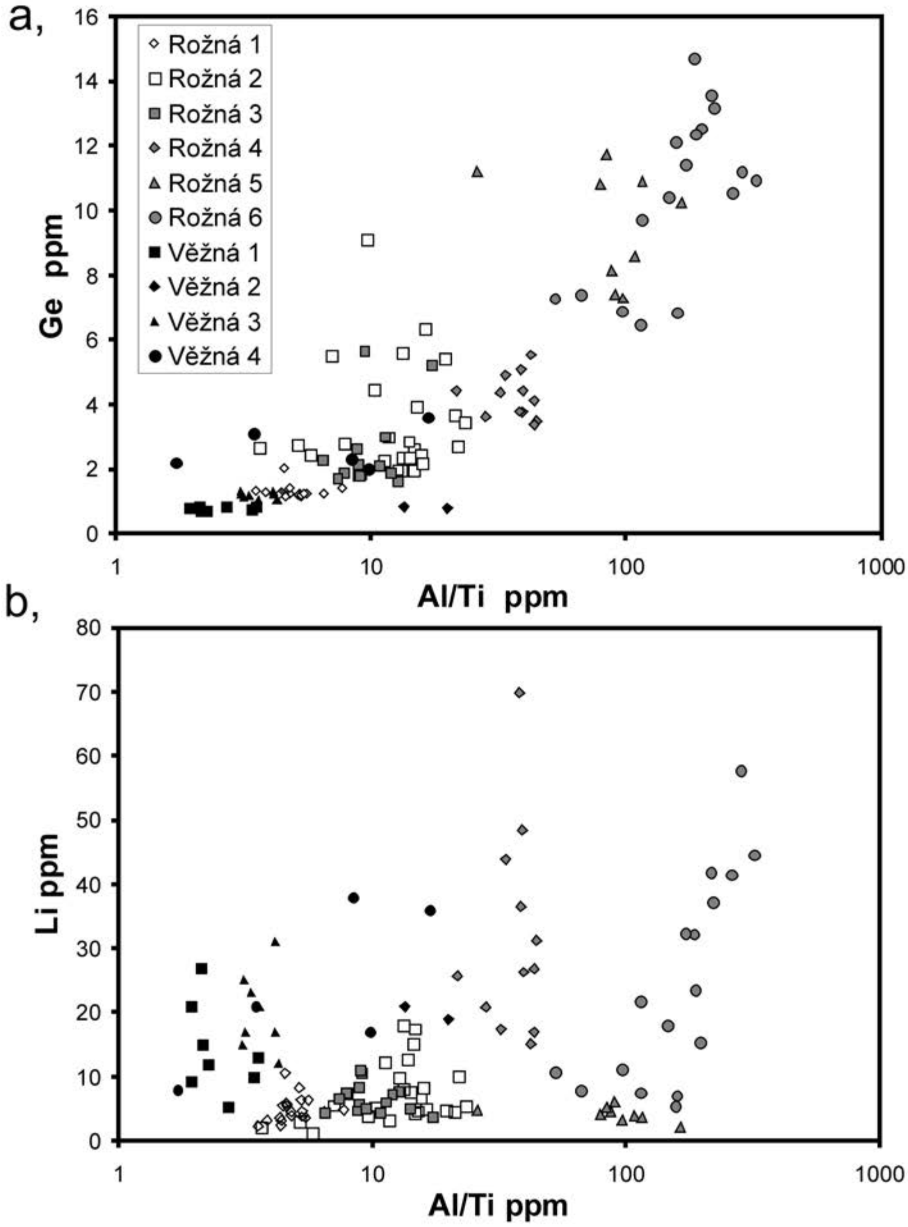

Fig. 1

Contents of Ge and Li in quartz from individual textural zones (from the margin to the core) in complex LCT pegmatites.

The Li contents in quartz increase systematically in lepidolite-free zones (= activity of Li in melt is high and Li enter quartz lattice), but strongly decrease in the lepidolite-bearing zone, where all Li preferentially incorporate into lepidolite and its activity in melt dropped. Thus, minerals crystallized from melt along with quartz may strongly influence the distribution of trace elements between quartz and melt.

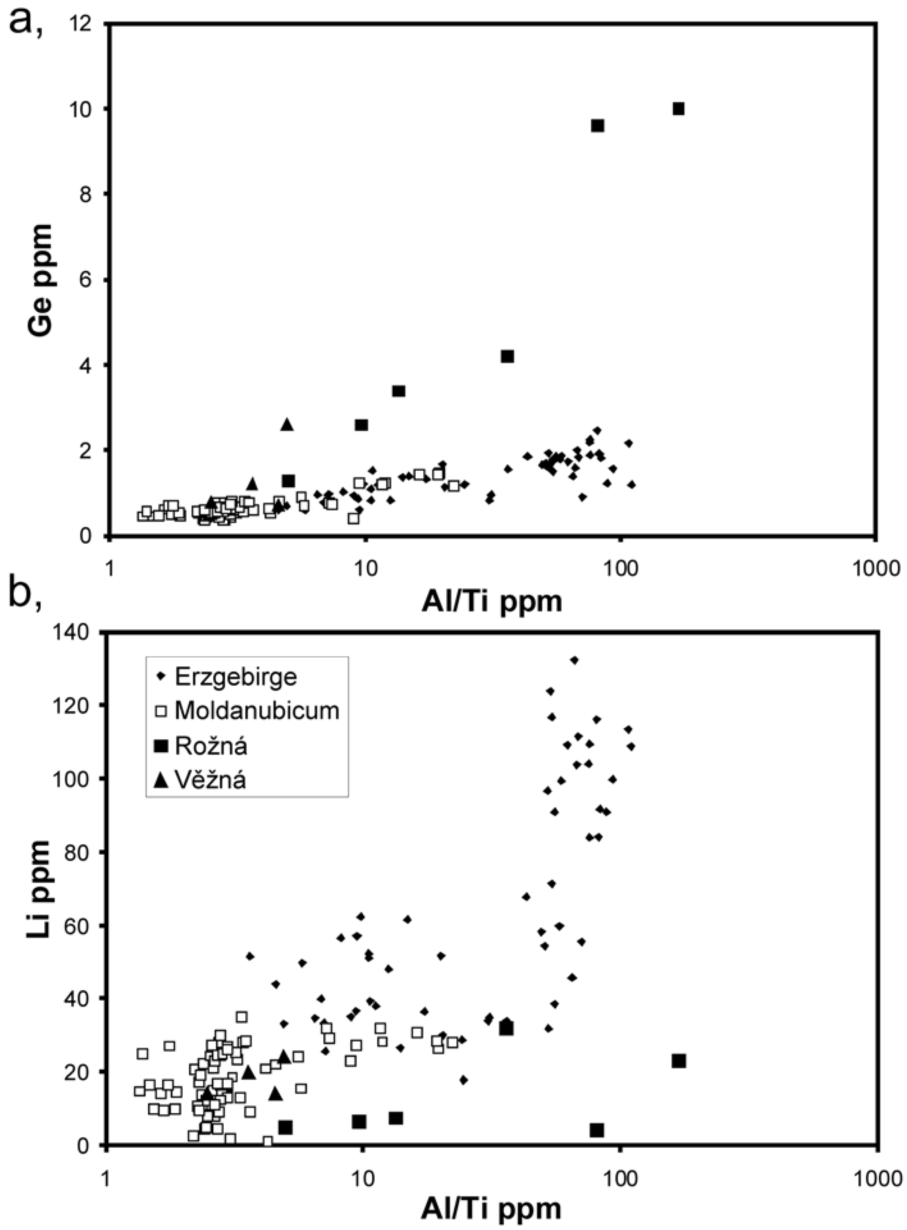

Fig. 2

Comparison of the Ge- and Li-contents in quartz from complex LCT pegmatites and peraluminous granites.

Fig. 2 illustrates comparison of Ge and Li contents in quartz from LCT-pegmatites and peraluminous granites. Contents of Ge in granites are mostly lower than 2 ppm. On the other hand, pegmatitic quartz, especially from the later stage of crystallization, tends to be strongly enriched in Ge with the concentrations up to 10-11 ppm in the albite-lepidolite zone and quartz core of Rožná pegmatite.

In case of Li, quartz from fractionated peraluminous granites in Erzgebirge contains 2-3 times more Li in comparison to late-stage zones of both studied pegmatites: crystallization of zinnwaldite in granitic melt was not able to block the entry of Li into quartz lattice.

Conclusions

Quartz from complex LCT pegmatites has similar evolutionary trend as quartz from fractionated granites: systematic increase of Al, Li, and Ge. In comparison with the most fractionated peraluminous granites, pegmatitic quartz is relatively depleted in Li, but strongly enriched in Ge. Minerals associated with crystallizing quartz may strongly influence the distribution of trace elements between quartz and melt. This influence is stronger in the pegmatitic than granitic melt.

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