POSSIBLE EXTRACTION SCALES OF ZINC AND LEAD BY H$_2$O-Cl FLUIDS FROM GRANITIC MAGMAS UNDER THEIR DEGASSING

Lukanin O.A., Dernov-Pegarev V.F. (GEOKHI RAS)
lukanin@geokhi.ru; Fax (495) 938-20-54; Phone (495) 137-44-72

Key words: magma degassing, granitic magma, fluid, chlorine, water, zinc, lead

Introduction. The exsolution of magmatic fluids from granitic magmas at their rise to the surface and crystallization is one of the most important factors in generation of ore-forming hydrothermal systems genetically related to granitic magmatism [1, 2 and others]. This communication presents numerical simulation results of Zn and Pb behavior during the degassing of H$_2$O- and Cl-bearing granitic magmas. Our computer model is based on experimental data generalization taking into consideration: a) the dependence of fluid-melt distribution coefficients for Cl, Zn and Pb on pressure and Cl concentration in the system; b) the possibility of fluid phase heterogeneity, i.e. its dividing into essentially aqueous and Cl-rich liquid phases in wide range of PTX conditions [3-5]. This model makes possible to make quantitative estimations of Zn and Pb extraction scales from magmas depending on (1) volatiles contents in melt; (2) the pressure of melt when its saturation with the volatiles is reached, (3) the crystallization degree and (4) dynamics of fluid phase escape from magmatic system.

Zn and Pb in fluids separated from granitic melts during decompression- and crystallization-assisted degassing. Cl and H$_2$O contents and their ratio in magmatic melts determine in many respects the Zn and Pb amounts extracted by fluid phases from magmas during their degassing. Fig.1 shows the influence of Cl content in the melt on Zn concentration change in the fluid phase formed during decompression degassing of granitic magmas (initial H$_2$O content in the melt ≈ 7.5 wt.%). In this case, the fluid saturation and degassing of the melt start at 3 kbar. The higher the initial Cl content in the melt the more is Zn concentration in the fluid phase and the more is extraction degree of ore component from the melt.
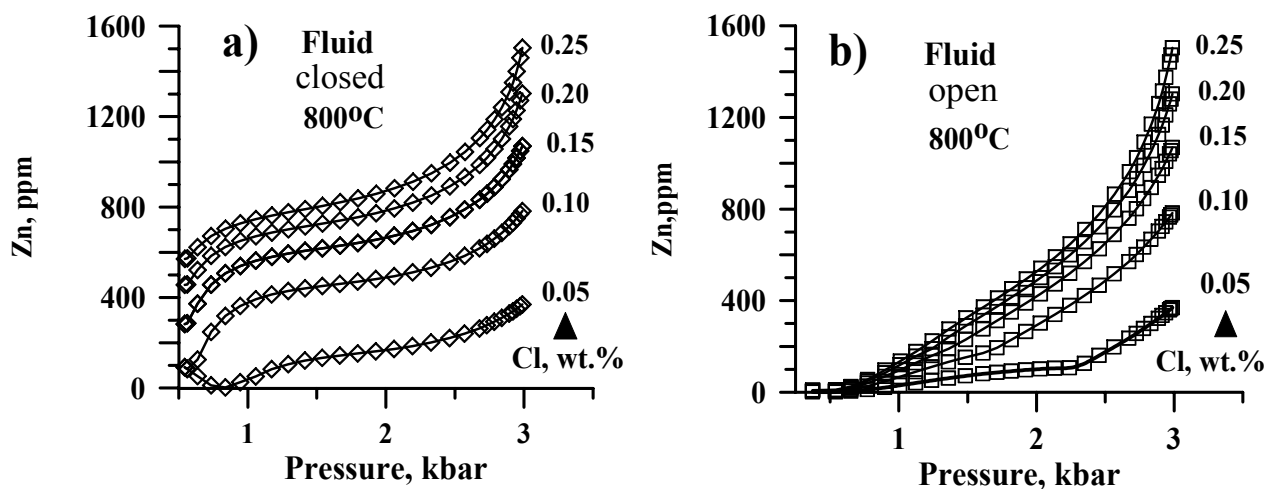

Fig 1. Zn concentration in the fluid phase formed during decompression degassing of granitic melts under closed (a) and open (b) conditions (numbers - initial content of Cl in the melt, wt.%).

As a result predominant amount of ore component is extracted from the melt by fluid phase during first deepest stages of decompression-assisted degassing. Fig. 2 demonstrates the amounts of Zn (a) and Pb (b) extracted by fluid phase in the process of decompression degassing of granitic melt under open conditions when exsolving fluid is able to completely escape from magmatic system. Numerical simulation results for the melt with mass of 2.3 x 10^9 t (10^6 m^3 by volume), containing 7.5 wt.% H$_2$O, 0.2 wt.% Cl and 100 ppm. Zn and Pb are shown. (Black columns - amounts of metal extracted within given pressure interval. Empty column - total amounts of metal extracted at this stage of melt uprising).
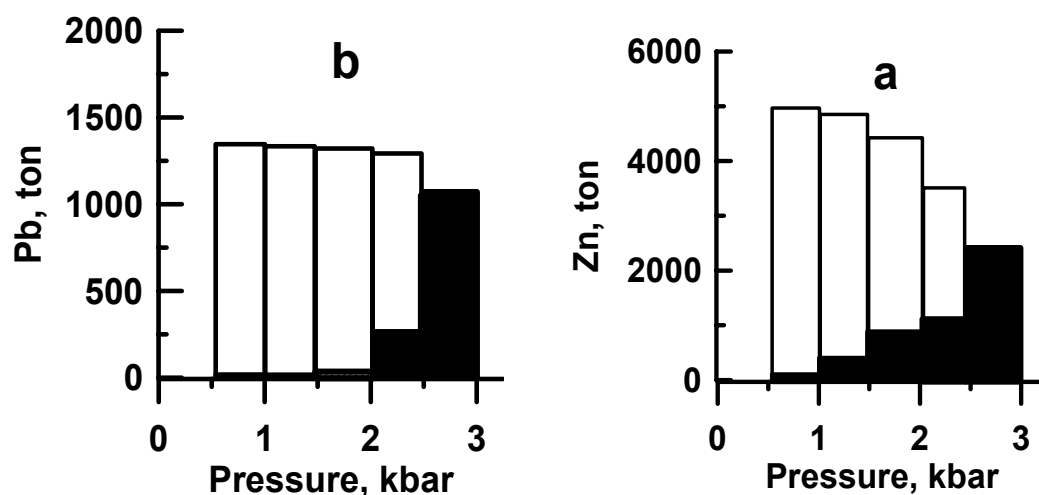
Fig.2. The amounts of Zn (a) and Pb (b) extracted from granitic melts during decompression degassing in open conditions. (Additional explanations see in the text.)

In the case of crystallization-assisted degassing the character of ore-forming elements extraction by H_2O-Cl fluids depends on the depth of magmas consolidation. The major part of ore-forming element is extracted at the earliest stages of degassing, if the degassing of fluid saturated melt occurs under high pressures (> 1.5 – 2.0 kbar). Fig.2 illustrates the case of crystallization-assisted degassing of the melt containing initially 0,2 wt.% of Cl 5.8 wt.% of H_2O and 100 p.p.m of ore metal under open conditions at pressure of 2 kbar. (Calculations were performed assuming D (Zn) crystals/melt = 0.6 and D(Pb) crystals/melt = 0.7.)
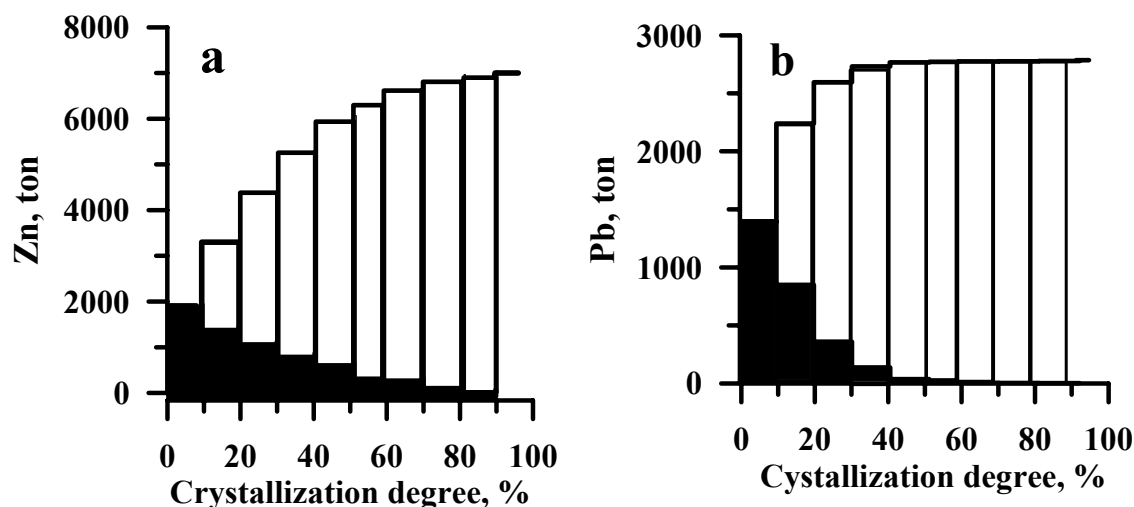

Fig.3. The amounts of Zn (a) and Pb (b) extracted by fluid phase from melt during its crystallization under open conditions at 2 kbar. (Additional explanations see in the text).

The crystallization-assisted degassing of fluid saturated melts at the shallow depth (P < 1 kbar) is accompanied by increase of Cl and ore elements concentrations in fluid phase both under closed and open conditions. The progressive increase of Cl content in fluid may lead to its heterogeneity i.e. the appearance of two coexisting phase water-rich solution (aq) and chloride-rich liquid (lq) at certain crystallization stage (fig 4a). The partition coefficients of Zn and Pb between lq and acid silicic melt D $(Me)_{lq/m}$ are roughly one order of magnitude higher than that ones of the same elements between aq equilibrated with the lq and the same melt $D(Me)_{aq/m}$. That is why with the appearance of lq under open conditions degassing we have abrupt increase in concentration values of these elements in the fluid and accordingly in its ore-carrying potential (fig. 4b).
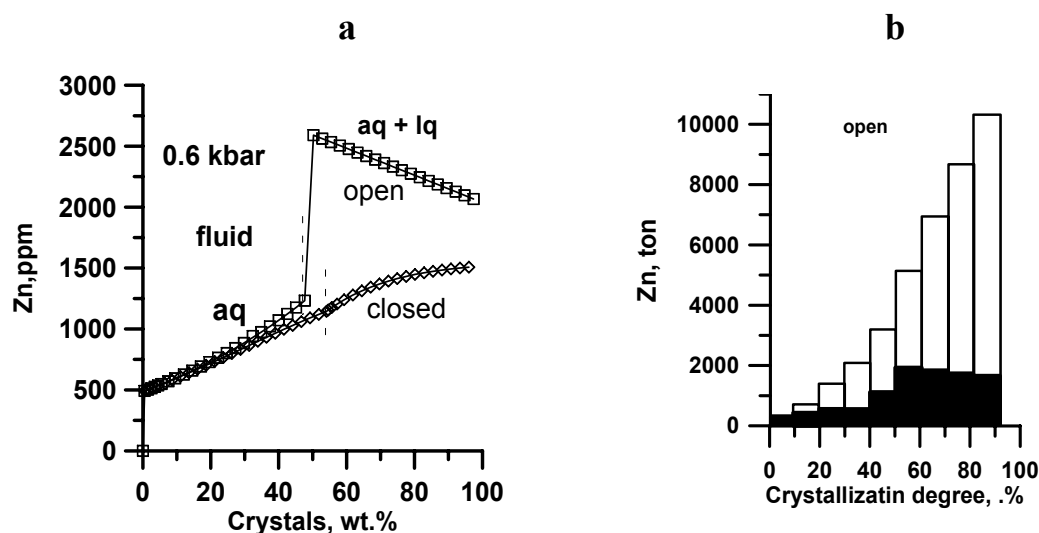
a   **b**

Fig.4. Degassing of granitic melt induced by its crystallization at 0.6 kbar: a) change of Zn concentration in fluid phase; b) Zn amounts extracted during crystallization of 2.3×10^6 tones of the melt under open conditions. Initial concentrations in the melt: 2.9 wt.% H_2O, 0.15 wt.% Cl, 100 ppm Zn. D(Zn)s/m = 0.6, D(Zn) lq/aq = 10. aq - H_2O-rich phase, lq - chloride liquid.

Conclusion. There are two the most favorable conditions for the formation of magmatic fluids with high chlorine and ore elements concentrations that are able to extract significant amount of metals from granitic magmas. The first one corresponds to the earliest stages of melt degassing caused by its rise to the surface and crystallization (at P>1.5–2.0 kbar). The second one is magma crystallization at shallow depth (<1.0 kbar) that may be accompanied with the formation of metals-enriched hypersaline brines. The results of numerical simulation confirm the statement that the quantities of ore-forming metals, extracted by magmatic fluids from granitic intrusions with initially Clarke concentrations of Zn and Pb may be quite sufficient for the formation of very large ore deposits. It should be noted that the total amount of extracted ore-forming elements essentially depends upon two factors: firstly, from volatile components contents in the melt (mainly from Cl concentration for such elements as Zn and Pb), secondly, upon the concrete mechanism of fluid phase separation from magmas during its degassing.

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