New interpretations on Liesegang ring-like structures in petrology

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This paper presents new interpretations on genesis of Liesegang ring-like structures in petrology. Examples of Liesegang ring-like structures in rocks are (1) periodic precipitates of iron hydroxide in hydrothermally altered rhyolite, (2) banded skarn between marble and granodiorite, and (3) a particular example of igneous layering from BiliBili alkaline intrusion, Sulawesi, Indonesia.

The key features of the Liesegang ring are periodic appearance of precipitates (rings) and the spacing law for the periodicity of the rings. The standard theory of the Liesegang ring is the supersaturation theory incorporating competitive particle growth (Ostwald ripening) model (e.g. Freeney et al.:1983). My new interpretations are based on a consideration of constraints on thermodynamic forces and their conjugate fluxes, which are not fully incorporated into the existing theory.

First I will discuss a classical example of a Liesegang ring in AgNO₃ - HCl system. Electrical neutrality condition gives a constraint on diffusive fluxes in this case. I assume that diffusion of H⁺ is much faster than those of other species. Uphill diffusion of Cl⁻ occurs due to the electrical neutrality condition if diffusivity of NO₃⁻ is larger or smaller than that of Ag⁺. The position of the ring formation is determined by that of the peak of Cl⁻ according to the supersaturation theory. This interpretation will be applicable to the example (1).

Secondly I will discuss more general situations in which the Gibbs - Duhem relation and the volume - fixed reference frame (a kind of conservation law) will give linear couplings among thermodynamic forces and fluxes, respectively. In such a case uphill diffusion can take place in a multicomponent system even for ideal solution (Nishiyama, 1998). As discussed by Nishiyama (1994), uphill diffusion will play a major role in formation of metamorphic layering. Similarly, uphill diffusion due to the linear couplings may cause Liesegang ring-like structure in banded skarn.

Finally I will discuss the origin of Liesegang ring-like structure in igneous layering from the same point of view.

References


N and Ar isotopes of fluid inclusion in Early Archean agate from North Pole area, Pilbara craton, West Australia

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Recently, carbonaceous filamentous structures were found in the Archean kerogen-rich silica dikes that have intruded basaltic greenstones from North Pole area in the Pilbara craton, West Australia. The origin of kerogen is debated. Some kerogen in the silica dykes contain N with C/N atomic ratio ~200 (Ueno, personal communication).

Here, we report N isotopic compositions for fluid inclusions in agate associated with the silica dikes, in order to evaluate the origin of fluid components and kerogen by investigating the relation between N from fluid components and that from kerogen. Peaks of H₂O, CO₂, N₂, CH₄ and H₂S were identified by Raman microspectrometry of the fluid inclusions. Crushing experiments showed that δ¹⁵N values and N₂/³⁶Ar ratios for the fluid components are ~6 ~ 0‰ and ~2.2*10⁴ ~ 9.9*10⁴ respectively. If these values for modern upper mantle (~5±2‰, 6±2*10⁶) and air (~0‰, 1.8±0.7*10⁴) (Sano et al., 1998) are applicable to Early Archean samples, N in the fluid inclusions can be explained by mixing of contemporary upper mantle and air. In addition, δ¹⁵N values for the fluid components can partly explain those of the kerogen (~4 ~ 4‰; Ueno, personal communication). Since N isotopic fractionation associated with biological N₂ fixation is small (~1 ~ 2‰; Wada, 1980), it may be possible that the origin of N in the kerogen is biologically fixed N₂ from contemporary fluid.

Figure1. A correlation diagram between δ¹⁵N values and N₂/³⁶Ar ratios for the fluid inclusions in agate.

References