Stretching and freezing processes of fluid inclusion density during the exhumation of metamorphic rocks

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Closure temperature of fluid inclusion density

Density and volume of fluid inclusions (FIs) are known to change during the retrogression of high-grade metamorphic rocks. Visible evidence of the deformation of FIs are recognized as decrepitation or implosion, which are often accompanied by satellite inclusions. However, existence of "mystic deformation" of FIs are also indicated by natural samples [1]. Such mystic deformation is caused by a ductile flow of the host phase driven by a pressure difference between inside and outside of FIs, and thus, occurs at lithostatic conditions. Recent study investigated the modification of FIs during ductile deformation of the host rock, revealing the compression of FIs by tectonic over-pressure taken place at approximately greenschist facies conditions [2]. These previous studies suggest the existence of "closure temperature" of the density of FIs, where the host minerals behave strong enough to freeze the density of enclosing FIs.

Model and results

This study constructs the deformation model of FIs during the exhumation of high-grade metamorphic rocks on the basis of flow law and physical properties of representative rock-forming minerals. We consider the deformation process of a spherical fluid inclusion filled with pure water emplaced within a homogeneous solid phase. Only differential pressure between fluid and host minerals are considered as the driving force of the deformation. The deformation follows the simple power-flow law. Given the *P*-*T* paths passing at lower-*P* side of the isochores of FIs, stretching of FIs are modelled. The results clearly predict a closure temperature of the density of FIs for each mineral, which can be defined by the temperature where flow-rate of the host mineral and expanding rate of the constituent fluid become similar in log-scale. Quartz gives a closure temperature ranging 300-400 ºC which is similar to the previous study [1], whereas garnet and olivine show the range of 700-800 ºC and 900-1100 ºC, respectively. These results suggest a potential of FI-geobarometer deciphering the exhumation and cooling *P*-*T* trajectories of high-grade metamorphic rocks.

[1] Küster and Stöckhert (1997) *Lithos* **41**, 151-167.
[2] Diamond and Tarantola (2015) *EPSL* **417**, 107-119.