

Episodic mineralization of hydrothermal illite in the Soultz-sous-Forêts granite (Upper Rhine Graben, France)

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Abstract Episodic and localized illite mineralization is documented in the hydrothermally altered Soultz-sous-Forêts granite (Upper Rhine Graben, France). Separated grain-size fractions of altered granite and argillite vein samples contain mixtures of $2M_1$ and $1M$ trans-vacant illite varieties. The platy pseudo-hexagonal $2M_1$ illite phases dominate the vein fillings, whereas the $1M$ illite occurs largely as a fibrous pore-filling variety, which is particularly abundant in the granite matrix. Multiple phases of fluid injections into the granite body have resulted in different illite assemblages, each sample containing a mixture of polytype generations formed during different crystal growth events. On the basis of mineralogical and K–Ar isotopic constraints, the ages of these vein-mineralizing events are determined by plotting the K–Ar values of the various grain-size fractions against polytype abundance and the fitted volume-weighted crystallite thickness distributions. The results suggest a Permian age for the formation of the studied argillite veins, characterized by successive injections of hydrothermal fluids. Secondary episodes

of illite crystallization occurred during Jurassic and Cretaceous (or even younger times) in both the veins and the granite matrix. There are indications that the polytype structure and composition of illite were strongly influenced by variations in fluid chemistry and the degree of fluid–rock interaction as the granite was progressively sealed during post-Variscan, episodic hydrothermal activity.

Keywords Illite · Hydrothermal fluids · Granite · Rhine Graben · Soultz-sous-Forêts · K–Ar age values · Permian veins

Introduction

Illite is recognized as an important mineral phase for reconstructing the geological history of fluid–rock interactions in most diagenetic, hydrothermal, and very-low-grade metamorphic settings (e.g. Clauer and Chaudhuri 1995; Inoue et al. 2004; Merriman and Frey 1999). The usefulness of this mineral relates to its widespread occurrence in the broad range of subsurface low-temperature geological environments (<300°C), its diverse crystal–chemical structure, and its relatively high K-content that allows it to be dated using well-established K–Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ isotopic techniques (Bailey et al. 1962; Hunziker et al. 1986; Clauer et al. 1995a, b, 2003; Imaoka et al. 2001; Altaner et al. 2003). Although there are known analytical complications associated with the reliable study of illite due to its small particle size and common mixed-layered structure, this mineral phase continues to provide a powerful tool for elucidating the timing and mechanisms of low-temperature crystallizations in rocks

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