Dislocation formation and albitization in alkali feldspars from the Shap granite

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ABSTRACT

Orthoclase-rich alkali feldspars in the Lower Devonian Shap granite, northwest England, contain two generations of albite-rich feldspar. These have partially replaced earlier exsolution microtextures consisting of albite lamellae (coarse semicoherent albite films and fine coherent albite platelets) in tweed orthoclase. The earlier generation of replacive albite-rich feldspar (\(\sim\)Ab\(_{90}\)An\(_9\)Or\(_1\)) occurs together with orthoclase-rich feldspar (\(\sim\)Ab\(_{60}\)Or\(_{30}\)) in veins that crosscut exsolution microtextures throughout grain interiors. This episode of recrystallization was mediated by magmatic fluids at \(\sim 410^\circ\)C (estimated from two-feldspar geothermometry) and was driven by stored elastic strain energy, which was relatively homogeneously distributed throughout the microtextures. The later generation of replacive albite-rich feldspar, which is restricted to grain margins and is compositionally pure (Ab\(_{99}\)), was produced by magmatic-hydrothermal fluids at \(\sim 370^\circ\)C. This generation of albite-rich feldspar does not crosscut exsolution microtextures and has selectively replaced volumes of highly elastically strained feldspar surrounding edge dislocations along semicoherent albite films. Marked differences in controls of the localization of the two generations of replacive albite-rich feldspar by pre-existing exsolution microtextures indicate that significant numbers of edge dislocations developed along albite films after the first phase of fluid-feldspar interaction and associated albitization but before the second phase. This relation indicates that edge dislocations formed between 410 and 370 \(^\circ\)C. These observations have important implications for understanding the factors that control the interaction of alkali feldspars with fluids both in cooling igneous rocks and in clastic sedimentary rocks during diagenesis.

INTRODUCTION

Recent studies of alkali feldspars from slowly cooled igneous rocks have demonstrated that feldspar microtextures are an invaluable source of information on thermal history (Brown et al. 1983; Waldron and Parsons 1992) and the evolution of fluids (Parsons 1978, 1980; Worden et al. 1990; Waldron et al. 1993; Brown and Parsons 1994; Walker et al. 1995). Alkali feldspars readily interact with magmatic fluids at temperatures of \(< 450^\circ\)C during cooling. This secondary or deuteritic alteration results in the replacement of pristine coherent or semicoherent exsolution microtextures by micropore-rich intergrowths of albite- and orthoclase-rich feldspar subgrains (termed “patch perthites” by Parsons 1978). These isochemical replacement reactions are driven by the relaxation of elastic strain energy accumulated as microtextures coarsen and transform during cooling (Brown and Parsons 1993); all alkali feldspars in slowly cooled rocks initially contain this stored elastic strain energy, and so all are potentially reactive. Deutritic alteration is geochemically important because radiogenic-argon leakage (Parsons et al. 1988) and O-isotope exchange (Waldron et al. 1993) may accompany recrystallization. Loss of coherency and formation of interconnected micropore networks also render volumes of deutERICally altered feldspar susceptible to weathering, following uplift and exposure, and to diagenetic reactions after erosion and sedimentation (Walker 1990, 1991; Lee and Parsons 1995; Walker et al. 1995). Hydrothermal alteration differs from deuteritic alteration by occurring in chemically distinct fluids originating outside the host rock; for example from the envelope of an igneous intrusion. As a consequence, substantial bulk chemical changes may accompany microtextural coarsening during hydrothermal alteration.

Most microtextural investigations of deuteric alteration have focused on feldspars that were initially largely coherent crypto- and microperthites of median bulk composition from hypersolvus syenites (Parsons 1978, 1980; Worden et al. 1990; Waldron and Parsons 1992). Although compositional and microtextural changes arising from deuteric alteration of these feldspars are now well understood, several questions remain. In particular, in many instances, grain boundaries and intragranular microtextures appear to exert little control on interaction with deuteric fluids (Worden et al. 1990). However, where coherent cryptoperthites have coarsened and partially lost coherency (for example by the formation of pleated rims at intergranular boundaries; Lee et al. 1997), alkali feld-