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Cretaceous age, composition, and microstructure of pseudotachylyte in the Otago Schist, New Zealand

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At Tucker Hill, in Central Otago, New Zealand, a series of pseudotachylyte veins are hosted in quartzofeldspathic schist. Chilled margins, microlites, flow banding, and the crystallisation of mineral phases absent from the host rock provide unequivocal evidence for melting during pseudotachylyte formation. Whole rock analyses of pseudotachylyte reveal c. 3 × enrichment of K_2O, Ba, and Rb, and similar depletion of Na_2O, CaO, Sr, and Eu, as compared to host schist. Formation age of pseudotachylyte is 95.9 ± 1.8 Ma as measured by total fusion $^{40}Ar/^{39}Ar$ analyses. Stepwise heating of pseudotachylyte matrix yields an excellently defined $^{40}Ar/^{39}Ar$ plateau age of 96.0 ± 0.3 Ma. These well-defined ages are attributed to the presence of potassium feldspar, low abundance of inherited lithic material from the host rock, and few fluid inclusions containing extraneous Ar. We propose that formation of these pseudotachylyte veins was related to Cretaceous extensional uplift and exhumation of the Otago Schist.

Keywords: pseudotachylyte; schist; Otago; Ar-Ar; geochronology; friction melting

Introduction

The presence of pseudotachylyte (former friction melt) in a fault zone is commonly attributed to frictional melting of rock during seismic slip (Sibson 1975). As such, pseudotachylytes are valuable indicators that an exhumed fault zone was seismically active. Pseudotachylytes have been described from inactive, ancient fault zones (e.g., Outer Hebrides Fault Zone: Sibson 1975; Maddock 1983; Kelley et al. 1994) and present day seismically active fault zones (e.g., the Alpine Fault: Sibson et al. 1981; Bossiere 1991; Warr et al. 2003). Determining the formation age of pseudotachylyte can reveal when a fault was seismically active, and provide information on the significance of a pseudotachylyte-bearing fault zone relative to the timing of other regional deformation events (Kelley et al. 1994; Magloughlin et al. 2001; Sherlock & Hetzel 2001; Mueller et al. 2002; Warr et al. 2003).

In Central Otago, New Zealand, a series of pseudotachylyte veins are found in schist outcropping on Tucker Hill (169° 24′23″E; 45° 15′16′S), near the township of Alexandra (Fig. 1). The pseudotachylyte veins are hosted in the garnet-biotite-albite zone of the greenschist facies of the Otago Schist, which forms the basement rocks of much of the Otago region (Mortimer 1993a, b). Tucker Hill is approximately 15 km to the east of the Cromwell Gorge Shear Zone and approximately 20 km to the south of the Rise and Shine Shear Zone, which are two Cretaceous age extensional shear zones (Deckert et al. 2002).

Previous studies that have attempted to determine the age of pseudotachylyte utilising $^{40}Ar/^{39}Ar$ geochronology in various localities have met with varying degrees of success. In particular, accurate and geologically meaningful $^{40}Ar/^{39}Ar$ age determinations are negatively influenced by the presence of variable amounts of inherited crystals (i.e., incompletely melted) from host rocks (Magloughlin et al. 2001; Warr et al. 2007), argon loss by diffusion or alteration (Davidson et al. 2003) or excess Ar in fluid inclusions (Di Vincenzo et al. 2004).

In this study, we document the petrography and geochemistry of pseudotachylyte veins, and present evidence for the origin of these pseudotachylyte veins as a friction melt. In addition, we report laser ablation $^{40}Ar/^{39}Ar$ total fusion, single-step infra-red laser heating ages, and stepwise heated $^{40}Ar/^{39}Ar$ analyses of fragments of pseudotachylyte matrix. Our results demonstrate excellent agreement between both total fusion and stepwise heating $^{40}Ar/^{39}Ar$ geochronology, which is attributed to the presence of potassium feldspar as the likely host for the majority of

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