A low-temperature
thermochronologic insight into the
thermal and exhumation history of
the eastern Musgrave Province, South
Australia

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A LOW-TEMPERATURE THERMOCHRONOLOGIC INSIGHT INTO THE THERMAL AND EXHUMATION HISTORY OF THE EASTERN MUSGRAVE PROVINCE, SOUTH AUSTRALIA

EXHUMATION OF THE EASTERN MUSGRAVE PROVINCE

ABSTRACT

Multi–method thermochronological data are presented for 12 Mesoproterozoic granitoid samples collected from the eastern Musgrave Province within South Australia. Interpretation of these data with the aid of time–temperature modelling allows inference of multiphase cooling histories. Apatite fission track (AFT) results indicate four discrete exhumation events that induced cooling through AFT closure temperatures (~60–120°C), supported by additional apatite (AHe) and zircon (ZHe) (U-Th-Sm)/He data. Late Neoproterozoic cooling from deep crustal levels to temperatures <200°C was observed, which is thought to be related with the Petermann Orogeny. Subsequent cooling events at ~450–400 Ma (Silurian – Devonian) and ~310–290 Ma (Late Carboniferous) are thought to represent exhumation associated with the Alice Springs Orogeny. The latter event exhumed the sampled eastern Musgrave plutons at shallow crustal depths. An additional Triassic – early Jurassic thermal event was observed throughout the study area, thought to be related to elevated geothermal gradients at that time. The high sample density across the structural architecture of the study area furthermore reveals patterns of differential exhumation and preservation of the thermal record, indicating more shallow exhumation levels in the centre and deeper exhumation towards the margins of the sampled transect. The observed differential exhumation patterns match with a model of an inverted graben system, demonstrating how low temperature thermochronological techniques can reveal fault reactivation patterns. The results highlight that the eastern Musgraves record a complex Phanerozoic low-temperature thermal history revealing the poorly appreciated tectonic evolution of inland Australia.

KEYWORDS

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Table 1: Sample location information, lithology, and applied methods. AFT = Apatite Fission Track, AHe = apatite U-Th-Sm/He, ZHe = zircon U-Th-Sm/He.

Table 2: Sample details, AFT results, and confined track length data for all samples. Averages of measured data are shown, where $\rho_s$ is the surface density of spontaneous fission tracks (in $10^5$ tracks/cm$^2$). $N_s$ is the number of counted spontaneous tracks, $N$ is the number of successful grains analysed. $^{238}U$ is the average $^{238}U$ concentration, measured by LA-ICP-MS (in $\mu$g/g). AFT age is the central age statistically generated for each sample (in Ma). Per sample, results of individual age peaks are labelled AFT Peak 1, 2, 3 (in Ma). $\sigma$ is the standard deviation (units dependent on result). For length data, $l_m$ is the average confined track length, $n$ is the number of confined tracks measured, and $\sigma_c$ is the standard deviation of confined track measurements.

Table 3: Apatite (U-Th-Sm)/He dating results. Concentrations for U, Th and Sm are in ng. Concentrations for $^4He$ are in ncc/μg. $F_t$ is the $\alpha$-ejection correction factor (Farley 2002). $He Age$ is given in Ma. AFT Age peaks (in Ma) for each sample are also indicated if they correlate well with He ages. $N$ is the number of grains analysed that contributed to each He age peak.

Table 4: Zircon (U-Th-Sm)/He dating results. Concentrations for U, Th and Sm are in ng. Concentrations for $^4He$ are in ncc/μg. $F_t$ is the $\alpha$-ejection correction factor (Farley 2002). $He Age$ is given in Ma. AFT Age peaks (in Ma) for each sample are also indicated if they correlate well with He ages. $N$ is the number of grains analysed that contributed to each He age peak.